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Kogrukluk River Salmon Studies, 2007

by

Derick L. Williams

Daniel J. Costello

and

Douglas B. Molyneaux

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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Douglas B. Molyneaux

Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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Derick L. Williams
derick.williams@alaska.gov

Daniel J. Costello
daniel.costello@alaska.gov

and

Douglas B. Molyneaux
doug.molyneaux@alaska.gov
Alaska Department of Fish and Game, Division of Commercial Fisheries,
333 Raspberry Road, Anchorage, AK 99518-1599, USA

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ABSTRACT

The Kogrukluk River produces Chinook salmon *Oncorhynchus tshawytscha*, chum salmon *O. keta*, sockeye salmon *O. nerka,* and coho salmon *O. kisutch* that contribute to intensive subsistence and commercial salmon fisheries downstream. Located in the upper Holitna River basin, which is a major tributary of the Kuskokwim River, the Kogrukluk River weir is one of several projects operated in the Kuskokwim Area that form an integrated geographic array of escapement monitoring projects. Collectively, and in accordance with the State of Alaska's Policy for the Management of Sustainable Salmon Fisheries (5 AAC 39.222), this array of projects provides the means to assess escapement trends that must be monitored and considered in harvest management decisions. Towards this end, the Kogrukluk River weir has been operated annually since 1976 to determine daily and total salmon escapements of returning salmon species; to estimate age, sex, and length compositions of Chinook, chum, and coho salmon escapement; to monitor environmental variables that influence salmon productivity; and to contribute to an integrated platform in support of other Kuskokwim Area fisheries projects.

In 2007, a fixed-picket weir was operated on the Kogrukluk River from 26 June through 23 September, with a total of 24 inoperable days. The total annual Chinook salmon escapement of 13,029 fish was near the upper boundary of the sustainable escapement goal (SEG) range of 5,300 to 14,000 fish. Total annual chum salmon escapement of 49,505 was slightly above the SEG range of 15,000 to 49,000 fish. Total annual sockeye salmon escapement of 16,525 was near the recent 10-year average (1997–2006) of 16,609 fish. The total annual coho salmon escapement of 27,033 was near the upper boundary of the SEG range of 13,000 to 28,000 fish. Age, sex, and length (ASL) samples were taken from 2.2% of the Chinook escapement, 1.3% of the chum escapement, and 1.5% of the coho escapement. The Chinook salmon escapement comprised 32.3% age-1.2 fish, 33.0% age-1.3 fish, 31.7% age-1.4 fish, 2.9% age-1.5 fish, and 28.4% females. The chum salmon escapement comprised 2.9% age-0.2 fish, 59.2% age-0.3 fish, 34.9% age-0.4 fish, 3.0% age-0.5 fish, and 37.6% females. The coho salmon escapement comprised 3.5% age-1.1 fish, 90.7% age-2.1 fish, 5.8% age-3.1 fish, and 44.6% females. Chinook, chum, and coho salmon all exhibited length partitioning by sex and age class. In addition to enumerating escapement and estimating ASL composition, the weir served as a platform for other projects, including *Kuskokwim River Chinook Salmon Run Reconstruction* and *Kuskokwim River Sockeye Salmon Investigations*. Furthermore, the weir project served as a sampling location for the collection of pink salmon (*O. gorbuscha*) and Dolly Varden (*Salvelinus malma*) genetic tissue.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, chum salmon, *O. keta*, coho salmon, *O. kisutch*, longnose suckers, *Catostomus catostomus*, escapement, age-sex-length, Kogrukluk River, Kuskokwim River, resistance board weir, radiotelemetry, mark–recapture, genetic stock identification, stock-specific run-timing, sockeye salmon, *O. nerka*, pink salmon, *O. gorbuscha*, Dolly Varden, *Salvelinus malma*

INTRODUCTION

Draining an area approximately 130,000 km^2 (11% of the total area of the state), the Kuskokwim River is the second largest river in Alaska (Figure 1; Brown 1983). Each year mature Pacific salmon *Oncorhynchus spp.* return to the river and its tributaries to spawn, supporting an annual average subsistence and commercial harvest of nearly 1 million salmon (Whitmore et al. 2008). The subsistence salmon fishery in the Kuskokwim Area is one of the largest in the state and remains a fundamental component of local culture (Coffing 1991; Coffing[1]; Coffing et al. 2000; Smith et al. *In prep*; Whitmore et al. 2008). The commercial salmon fishery, though modest in value compared to other areas of Alaska, has been an important component of the market economy of lower Kuskokwim River communities (Buklis 1999; Whitmore et al. 2008). Salmon contributing to these fisheries spawn and rear in nearly every tributary of the Kuskokwim River basin.

[1] Michael Coffing, Alaska Department of Fish and Game, Division of Subsistence, Bethel. Reports prepared for the Alaska Board of Fisheries, Fairbanks, Alaska, December 2, 1997. *Kuskokwim area subsistence salmon harvest summary, 1996*, and *Kuskokwim area subsistence salmon fishery*;.

Since 1960, management of Kuskokwim River subsistence, commercial, and sport fisheries has been the responsibility of the Alaska Department of Fish and Game (ADF&G), though management authority for the subsistence fishery was broadened in October 1999 to include the federal government under Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA). The U.S. Fish and Wildlife Service (USFWS) is the federal agency most involved within the Kuskokwim Area. In addition, numerous tribal groups are charged by their constituency to actively promote a healthy and sustainable subsistence salmon fishery. For years, these and other groups have combined their resources in an effort to achieve long-term sustainability of Kuskokwim River salmon.

Proper salmon management provides for long-term sustainable fisheries by ensuring that adequate numbers of salmon escape to the spawning grounds each year. However, few spawning streams have received rigorous salmon escapement monitoring. Consequently, critical long-term salmon escapement data are lacking for much of the Kuskokwim River drainage, which has limited the ability of managers to assess the adequacy of escapements and the effects of management decisions. Historically, only 2 long-term ground based projects have operated in the Kuskokwim River drainage: the Aniak River sonar and the Kogrukluk River weir (Molyneaux and Brannian 2006). The need for long-term escapement information prompted the establishment of several weir projects throughout the late 1990s. Currently, 8 ground-based escapement monitoring projects, consisting of 7 weirs and one sonar project, are operated cooperatively by a variety of state, federal, and tribal organizations (Molyneaux and Brannian 2006). This array of projects allows managers to monitor the status of individual salmon stocks as well as track drainage-wide trends that may reflect overall ecosystem health.

During recent Alaska Board of Fisheries (BOF) meetings, Kuskokwim River Chinook *O. tshawytscha* and chum *O. keta* salmon have received considerable attention due to erratic run abundance patterns. In 2000, the BOF designated Kuskokwim River Chinook and chum salmon as “stocks of yield concern” after several years of lower than expected harvest levels (Burkey et al. 2000a, b). This “stock of yield concern” designation was upheld during the 2004 BOF meeting (Bergstrom and Whitmore 2004) but was cancelled during the 2007 BOF meeting at the recommendation of ADF&G following several years of expected harvest levels and relatively strong escapements (Linderman and Bergstrom 2006; Molyneaux and Brannian 2006). Between 2001 and 2006 subsistence and commercial fisheries were managed conservatively and in accordance with the BOF “stocks of yield concern” designations. Efforts were focused on enumerating abundance of these species and obtaining enough data for escapement goal development. Several main-river and regional projects were initiated that utilized the existing weir infrastructure for data collection. Such projects have since become deeply integrated components of field operations.

The utility of weirs extends beyond providing annual escapement estimates. Escapement projects, such as the Kogrukluk River weir, commonly serve as platforms for collecting other types of information useful for management and in other research initiatives. Collection of age, sex, and length (ASL) data are typically included in most escapement monitoring projects (Molyneaux et al. *In prep*), and the Kogrukluk River weir is no exception. Knowledge of ASL composition can improve understanding of fluctuations in salmon abundance and is essential for developing spawner-recruit relationships that are investigated when formulating escapement goals (Molyneaux and Brannian 2006). The Kogrukluk River weir also serves as a platform for collecting information on habitat variables including water temperature, water chemistry, and stream discharge (level), which are fundamental variables of the stream environment that directly or indirectly influence salmon productivity and timing of salmon migrations (Hauer and Hill 1996; Kruse 1998; Quinn 2005). Since these variables can be affected by human activities (i.e., mining, timber harvesting, man-made impoundments, etc.; NRC 1996) or climatic variability (e.g., El Nino and La Nina events), and/or climate change (e.g. global warming), data collection for such variables are included in the project operational plan.

BACKGROUND

Regional

In the dialect of the upper Kuskokwim River Yupik people, Kogrukluk means "middle fork" (Evan Ignatti, elder, Kashegelok; personal communication). In the early 1800s, the Holitna River was an important component in the Russian fur-trading industry because it, coupled with the Nushagak River, served as a route for travel between Bristol Bay and the Kuskokwim River (Oswalt 1990). About twice each year, Russian explorers and traders traveled this route, completing a 5 day portage between Shotgun Creek and the Chichitnok River (Brown 1983; Oswalt 1990). Until 1845, this served as the primary supply route to the first Russian station on the Kuskokwim River, which was located at the mouth of the Holitna River. To service this trade route, a number of communities were established along the Holitna River including Kashegelok, Nogamut, and Itulilik. Residents of Holitna River communities relied heavily on the abundant Holitna River salmon runs for subsistence, but supplemented their livelihoods through the fur trade.

As the fur trade declined and other opportunities arose, such as the opening of the Red Devil mercury mine in the 1930s, the Holitna River villages were slowly abandoned. Kashegelok, located just downstream from the Kogrukluk/Chukowan confluence, was perhaps the longest surviving Native community along the Holitna River. Kashegelok harbored a sizable community until most of the dwellings were destroyed when the Holitna River shifted course to the east sometime between 1940 and 1960 (Evan Ignatti, elder, Kashegelok; personal communication). The last 2 individuals claiming ties to Kashegelok, Evan Ignatti and Ignatti Ignatti, relocated to Red Devil when a gravel bar formed across a portion of the channel favored as a floatplane landing site after the Chukowan River shifted course during the spring flood of 2003.

Today, most human inhabitants of the Holitna River reside in a number of commercial lodges and private, usually single-family, homesteads along the lower Holitna River. The Holitna River drainage continues to draw users from throughout the Kuskokwim River drainage and beyond, and remains an important area for subsistence fishing, sport fishing, and hunting.

Kogrukluk River Escapement Monitoring

Since the first aerial survey was flown in 1961, state managers have recognized the importance of the Holitna River drainage as a salmon spawning system (Burkey 1994; Schneiderhan[2]). In 1969, managers initiated a ground-based escapement-monitoring program on the Kogrukluk River, which was found to support sizable populations of salmon and had characteristics that facilitated salmon enumeration. Annual salmon escapement to the Kogrukluk River has been monitored since 1969, making it the longest and most consistent historical escapement dataset of all Kuskokwim Area projects.

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[2] Schneiderhan, D. J., editor. Kuskokwim stream catalog, 1954 1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

Escapement monitoring began in 1969 when a salmon counting tower project was initiated on the Kogrukluk River upstream of the confluence of Shotgun Creek (Figure 2; Yanagawa 1972). The tower was relocated twice between 1970 and 1978 because of shifting river channels, but always remained upstream of the mouth of Shotgun Creek. In order to more accurately assess salmon escapements, installation of a counting weir was attempted in 1971 near the counting tower site. Unfortunately, this first weir was destroyed by high water early in the season (Yanagawa 1973). Both tower and weir operations in this section of the Kogrukluk River were hindered by log jams and shifting channels. Inadequacies of the existing tower sites and the absence of more suitable locations resulted in a transition from a counting tower to a weir between 1976 and 1978 (Baxter 1979). Because the weir was located below the confluence of Shotgun Creek, both tower and weir projects were operated concurrently from 1976 to 1978 to compare escapement estimates between projects.

Since its inception in 1976, the Kogrukluk River weir (sometimes referred to as the Ignatti weir or Holitna River weir) has operated annually to monitor Chinook, chum, and sockeye (*O. nerka*) salmon escapement to this system. Beginning in 1981, the weir operations were extended to include coho salmon (*O. kisutch*; Baxter 1982). Since the late 1990s the Kogrukluk River weir has served several regional mark-recapture based projects including *Kuskokwim River Chinook Salmon Run Reconstruction* (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication), *Inriver Abundance of Chinook Salmon in the Kuskokwim River* (Stuby 2007), *Kuskokwim River Sockeye Salmon Investigations* (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication), *Kuskokwim River Salmon Mark-Recapture Project* (Pawluk et al. 2006), and *Assessment of Chinook, Chum, and Coho Salmon Escapements in the Holitna River Drainage Using Radiotelemetry* (Stroka and Brase 2004; Stroka and Reed 2005). Furthermore, genetic tissue samples have been obtained from all species of Pacific salmon as well as Dolly Varden in support of various genetics-based large-scale studies.

Kogrukluk River salmon escapements are a relatively small percentage of overall salmon escapements in the Kuskokwim River drainage; however, this tributary appears to support a relatively large number of spawning Chinook, chum, sockeye, and coho salmon when compared to other Kuskokwim River tributaries of similar size (Molyneaux and Brannian 2006). The Kogrukluk River weir is 1 of only 3 ground-based projects in the Kuskokwim River drainage with a formal escapement goal for Chinook salmon, 1 of only 2 projects with a formal escapement goal for chum salmon, and the only project with a formal escapement goal for coho salmon (Figure 1; Brannian et al. 2006b).

OBJECTIVES

The objectives of the Kogrukluk River escapement monitoring project in 2007 were to:

1. Determine the daily and total annual escapement of male and female Chinook, chum, sockeye, and coho salmon to the Kogrukluk River;

2. Estimate the age, sex, and length (ASL) composition of total annual Chinook, chum, and coho salmon escapements from a minimum of 3 pulse samples, one collected from each third of the run, such that 95% simultaneous confidence intervals for the age composition in each pulse are no wider than 0.20 (α = 0.05 and d = 0.10);

3. Monitor habitat variables including daily water temperature and daily water level.

4. Provide for collaborative, efficient research in the Kuskokwim River system by:
    a. Serving as a monitoring and recapture location for Chinook salmon equipped with radio transmitters and anchor tags deployed as part of *Kuskokwim River Chinook Salmon Run Reconstruction*;
    b. Serving as a monitoring and recapture location for sockeye salmon equipped with radio transmitters deployed as part of *Kuskokwim River Sockeye Salmon Investigation*;
    c. Serving as a collection site for Dolly Varden (*Salvelinus malma*) genetic tissue samples as part of the *Baseline development for Dolly Varden in southwestern Alaska* project; and
    d. Serving as a collection site for pink salmon genetic tissue.

The primary goal of this report is to summarize and present the results for the 2007 field season at the Kogrukluk River weir. Secondary to this, we intend to provide a more holistic perspective of Kuskokwim Area fisheries by placing the 2007 findings into the broader spatial and temporal context. To do this we draw heavily on data from past years at this project to highlight between-year trends, and we draw on data from other escapement monitoring projects, related research projects, and the commercial and subsistence fishery in order to highlight spatial trends. These goals are intended to enhance the utility of this report beyond simply archiving data. It is important to note that some of the data used to make these broader comparisons are preliminary. Effort was made to ensure that all preliminary data was reported as such. In addition, many of the referenced documents are currently being developed. Consequently, most of the reported trends for other projects were determined by the authors of this report based on data sets generously provided by other researchers. At the time of publication of this document all reported estimates and trends are as accurate as possible. However, the final results and conclusions for "*In prep*" documents may change. Therefore, readers should consult the original documents prior to referencing results from other projects, especially those listed as "*In prep*". Furthermore, unless stated, the statistical significance of the trends discussed for this and other escapement monitoring projects have not been determined. Many of these trends are subjective and based on low sample sizes with high variance. It is important to remember that sampling methodologies often differ across projects and over time leading to difficulty in comparisons. Throughout this document every effort was made to ensure sound comparisons. However, the reader should be aware of these potential issues and view broader spatial and temporal trends with caution.

METHODS

STUDY AREA

The Kogrukluk River drains a watershed of about 2,073 km^2 that is formed by surface runoff from a low plateau that divides the Tikchik Lakes system and Nushagak River basin from the Holitna River basin. From its headwaters near Nishlik Lake, the Kogrukluk River flows northerly for approximately 80 river kilometers (rkm). The Kogrukluk River joins Shotgun Creek upstream of the weir site and the Chukowan River below the weir site, near the abandoned village site of Kashegelok. The confluence of the Chukowan and Kogrukluk Rivers forms the headwaters of the Holitna River (Figure 2). The Holitna River joins the Kuskokwim River at rkm 491, and the Kogrukluk River is an additional 218 rkm upstream of the confluence.

Over its course, the Kogrukluk River descends approximately 250 m with an average drop of 3.2 m per km across a 1-5 km wide flood plain (Figure 3; Collazzi 1989). The flood plain is poorly drained and is composed of soft sediments that erode easily. The substrate is mostly gravel and cobble of assorted sizes. At normal flow, the Kogrukluk River has a nominal load of suspended materials and the water is clear; however, water clarity is reduced during periods of high flow when it can become stained from organic leaching. The Kogrukluk River and its tributaries are dynamic in that they can change course quickly. The resulting oxbows, sloughs, and large log jams form a complex mosaic of reproductive habitat suitable for salmon (Baxter[3]; Healy 1991).

Riparian areas consist of low-lying mixed spruce (*Picea spp.*), cottonwood (*Populus sp.*), willows (*Salix spp.*), and alders (*Alnus spp.*), interspersed with wet tundra. Uplands are typically spruce-hardwood forest, and terrain above 200 m is typically alpine tundra. White spruce (*P. glauca*), birch (*Betula spp.*), and aspen (*P. trenuloides*) are common on moderate south-facing slopes and black spruce (*P. mariana*) is common on north-facing slopes, in poorly drained areas, and within pockets of permafrost. On cool moist slopes the understory consists of spongy moss and low brush on cool moist slopes, whereas on dry slopes the understory is mostly grasses and near timberline most understories consists of willows, alders, and dwarf birch (*B. nana*).

WEIR DESIGN

Installation Site

Located approximately 220 rkm from the village of Sleetmute, 710 rkm from the mouth of the Kuskokwim River, and 212 km by air from the city of Bethel, the Kogrukluk River weir is the most remote ground-based escapement project in the Kuskokwim Area (Figure 1). Personnel and supplies are transported to and from the weir by floatplane. The weir has been at this location since 1976 (Baxter[4]).

The river channel at the weir site is a relatively stable, but lies on a dynamic floodplain that experiences relatively frequent changes in channel location and morphology. The weir is located on the Kogrukluk River between the confluence of Shotgun Creek, which is 3 rkm upstream, and the Chukowan River, which is 1 rkm downstream (Figure 2). Together, these 3 tributaries comprise the headwaters of the Holitna River. Areas further downstream are considered unsuitable due to excessive water depth, channel width, and braided stream morphology.

At the weir site the Kogrukluk River is approximately 70 m wide and 3–4 m deep at full capacity. During normal summer operations river depth is about 1.3 m in the deepest section. The weir is positioned in the center of a 2 km stretch of relatively straight channel. Banks are composed of soft sediment and bottom material is primarily composed of gravels and cobbles. The weir site is at the base of a southwest-facing hillside.

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3 Baxter, R. Hoholitna River reconnaissance survey, 1977. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Resource Report No. 3, Anchorage.

4 Baxter, R. Holitna Weir developmental project, 1976. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Escapement Report No. 11, Anchorage.

Construction

The Kogrukluk River weir is a fixed-picket design that has changed little since the weir was first installed in 1976 (Baxter 1981). Recent changes include the incorporation of an improved fish trap and tighter picket spacing. The use of the new fish trap began in 1999 and the new picket spacing was first used in 2005. The fish trap, which is about 1.5 m by 2.5 m, was modeled after the trap used at the George River weir since 2001 (Linderman et al. 2003). The picket spacing was narrowed after investigators observed small chum salmon passing through the pickets in 2004, a year that was characterized by an unusually high abundance of small, 3 year old chum salmon. Picket intervals were reduced from 76.2 mm to 63.5 mm, which narrowed the gap from 49.0 to 36.5 mm (R. Stewart, Commercial Fisheries Technician, ADF&G, Anchorage; personal communication). When installed, the weir spans a 70 m channel, with a fish trap located 30–50 m from the east bank. A boardwalk is constructed above the weir from the east bank to the fish trap to facilitate access to the trap.

The weir design does not allow boats to pass without partially dismantling the weir. Boat traffic at the weir is uncommon; however, boats can be passed by removing weir pickets and pulling the boat through the opening when necessary (Baxter 1981). The use of a floating resistance board weir, which is generally better at accommodating debris and boat traffic, was considered for this site but extensive site surveys indicated that the weir location lacked the necessary homogenous riverbed profile and substrate stability for proper installation and operation of a floating weir (Shelden et al. 2005).

Maintenance

The weir is cleaned and inspected at least once each day. Small debris that accumulates around the weir pickets (sticks, leaves, fibrous root mats, small logs, algae, and fish carcasses) are removed and passed downstream. Large debris, such as large logs and root clumps, are removed using chainsaws, axes, and rope. Sometimes larger debris requires partial dismantling of the weir.

The daily cleaning routine includes a visual inspection of the weir for conditions that could compromise weir operations, such as substrate scouring or damaged pickets. Periodically the crew conducts a more thorough inspection by snorkeling along the leading edge of the weir. Problems are addressed immediately. Incidences of substrate scouring are rectified with sandbags or comparable means.

ESCAPEMENT MONITORING

The Kogrukluk River weir project differs from other weir projects in the Kuskokwim River drainage in that it has not operated based on a target operational period (see *Recommendations* section). The weir is usually installed in mid June is operated late into September; however, the actual operational period varies annually. These dates are usually sufficient to encompass nearly the entire runs of Chinook, chum, and sockeye salmon as well as the bulk of the coho salmon. Generally, no attempt is made to estimate missed passage prior to installation and/or after removal of the weir. High water events or damage to the weir occasionally result in inoperable periods. Estimates of salmon passage for inoperable periods help to provide consistent comparisons of escapements among years. Total annual escapement is determined from the total observed and estimated fish passage.

Passage Counts

The live trap is used as the primary means of upstream fish passage. Fish are counted as they entered the downstream end of the trap. Identification is improved through the use of a clear-bottom viewing box that reduces glare and water turbulence. In addition to aiding in species identification, this tool allows observers to see and thus trap tagged fish in support of tag-based projects, such as *Kuskokwim River Chinook Salmon Run Reconstruction* and *Kuskokwim River Sockeye Salmon Investigations*. Other methods are occasionally used when salmon are reluctant to enter the fish trap, such as during periods of extreme low water. Liller et al. (2008) describes other methods.

Small fish that pass between the weir pickets are not enumerated. Since picket spacing was reduced in 2005 the occurrence of this type of passage has been considered negligible for all salmon species except pink salmon. Complete enumeration of pink salmon is not possible for this reason. Consequently, reported pink salmon abundance reflects only the number of fish observed passing the weir through the counting location during normal enumeration routines. No effort is made to estimate pink salmon escapement during periods of inoperability due to methodology limitations and reduced confidence. Regardless, the escapements of pink salmon reported are underestimates of actual abundance.

Counting sessions are typically performed 4 to 8 times per day between 0730 and 2400 and typically last about 1 hour. This schedule can be adjusted as needed to accommodate variation in fish behavior and abundance. Crew members visually identify the species and sex of each fish observed passing upstream of the weir. Counts are maintained on a multiple-tally counter and later recorded in a logbook. Passage data are reported each morning to ADF&G staff in Bethel via single side band radio or satellite phone.

Estimating Missed Passage

To better assess annual run size of each species of salmon and to facilitate comparison among years, upstream salmon passage is estimated for days when the weir is not operational during the season. When historical data indicate that passage of a particular species on an inoperable day is probably negligible, passage is assumed to be zero without performing any calculations. However, when historical records indicate that passage of a particular species is probably considerable, 1 of the 3 formulas listed below are used to calculate potential missed passage. The method used depends on the duration and timing of the inoperable periods.

Single Day

When the weir is not operational for part or all of one day, an estimate for the inoperable day is calculated using the following formula:

$$\hat{n}_{d_i} = \left(\frac{\left(n_{d-2} + n_{d-1} + n_{d+1} + n_{d+2} \right)}{4} \right) - n_{o_i} \qquad (1)$$

where

$n_{d_I-1}, n_{d_I-2} =$ observed passage of 1, 2 days before the weir was washed out;

$n_{d_I+1}, n_{d_I+2} =$ observed passage of 1, 2 days after the weir was reinstalled; and,

$n_{o_i} =$ observed passage (if any) from the given day (*i*) being estimated.

Linear Method

When the weir is not operational for 2 or more days and later becomes operational, passage estimates for the inoperable days are calculated using the following formula:

$$\hat{n}_{d_i} = (\alpha + \beta \cdot i) - n_{o_i}$$
$$\alpha = \frac{n_{d_1-1} + n_{d_1-2}}{2} \tag{2}$$
$$\beta = \frac{\left(n_{d_I+I} + n_{d_I+I+1}\right) - \left(n_{d_1-1} + n_{d_1-2}\right)}{2(I+1)}$$

where

I = number of inoperative days ($I > 2$), and

n_{d_I+I}, n_{d_I+I+1} = observed passage the first day after the weir was reinstalled.

Proportion Method

In circumstances when the weir does not first become operational until well into the one or more salmon runs, or when the weir ceases operating before data suggest salmon runs are nearing completion, daily passage for inoperable days is estimated using passage data from another year at the Kogrukluk River weir or from a neighboring project. The dataset used to model escapement for a particular situation is selected because it exhibits similar passage patterns to the incomplete dataset. With this method, daily passage estimates are calculated using the following formula:

$$\hat{n}_{d_i} = \left(\frac{\left(n_{md_i} \times \sum n_{d_1}\right)}{\sum n_{md_1}} \right) - n_{o_i} \tag{3}$$

where

n_{md_i} = passage for the i^{th} day in the model data;

$\sum n_{d_1}$ = cumulative passage;

$\sum n_{md_1}$ = cumulative passage of the model data for the corresponding time period; and,

n_{o_i} = observed passage (if any) from the given day (i) being estimated.

Estimates Required in 2007

The "linear method" was used to estimate missed Chinook, chum, sockeye, coho, and pink salmon passage for all inoperable periods that occurred during the 2007 season. This method has been used annually since 2003 but varies from previous years. Clark and Salomone (2002) describe details of the methods used for estimating missed daily passages prior to 2003.

Carcasses

Each time the weir is cleaned, spawned-out salmon (hereafter referred to as carcasses) that washed up on the weir are counted by species and discarded downstream. Daily and cumulative carcass counts are copied to logbook forms.

AGE, SEX, AND LENGTH COMPOSITION

Sample Collection

The field crew at the Kogrukluk River weir employed standard sampling techniques as described by DuBois and Molyneaux (2000). For chum and coho salmon, a pulse sampling design was used in which moderate sampling was conducted for 3 to 5 days followed by a few days without sampling. The goal of each pulse was to sample 200 chum and 170 coho salmon.

The pulse sample design was not strictly followed with Chinook salmon. The goal to sample a minimum of 210 Chinook salmon from each third of the run superseded the goal to sample in pulses. Consequently, Chinook salmon samples were collected throughout most of the run.

Sample size goals were selected so the simultaneous 95% confidence interval estimates of age and sex composition proportions would be no wider than 0.20 per pulse (Bromaghin 1993). Furthermore, sample sizes were chosen based on the assumed number of age/sex categories in the population and the number of samples needed to properly define each category. Based on historical determination of age/sex structure within Kuskokwim River salmon populations, investigators assumed 10 age/sex categories for Chinook salmon, 8 age/sex categories for chum salmon, and 6 age/sex categories for coho salmon. Target sample sizes for all species were increased by about 10% from those recommended by Bromaghin (1993) to accommodate scale loss (i.e. sampled individuals that could not be aged). The minimum acceptable number of sampling events was 3 per species, one event from each third of the run, to account for temporal dynamics in the ASL composition.

Comprehensive sampling of sockeye salmon at the Kogrukluk River weir was discontinued in 1995 because widespread scale absorption precludes reliable age determination. A number of sockeye salmon have been sampled in 2006 and 2007 in support of a separate project entitled *Kuskokwim River Sockeye Salmon Investigations* (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication), hereby referred to as the Sockeye Investigations Project. Sampling requirements of the Sockeye Investigations Project were not as rigorous as those for other species or for those employed on sockeye salmon before 1995. Consequently, sockeye salmon ASL data from 2006 and 2007 are not readily comparable with historical data collected before 1995.

Salmon were sampled from the fish trap installed in the weir. The trap included an entrance gate, holding pen, and exit gate. On days when sampling was conducted, the entrance gate was opened while the exit gate remained closed, allowing fish to accumulate inside the 8 by 5 ft (2.4 by 1.5 m) holding pen. The holding pen was typically allowed to fill with fish and sampling was conducted during scheduled counting periods. Additional Chinook samples were collected through the process of “active sampling”, which consisted of capturing and sampling Chinook salmon while actively passing and enumerating all fish. Every fish of the target species was measured for length to the nearest millimeter from the center of the eye (mid eye) to tail fork (METF) and identified as male or female through visual examination of the external morphology. Depending on the species being sampled one or 3 scales were removed from the preferred area of the fish (INPFC 1963). Scales were affixed to gum cards and sent to ADF&G staff for processing (i.e. age determination).

After sampling was completed, relevant information such as sex, length, sampling date, and sampling location was copied to computer mark-sense forms that correspond to numbered gum cards. The completed gum cards and mark-sense forms were sent to the Bethel and/or Anchorage ADF&G offices for processing. The original ASL gum cards, acetates, and mark-sense forms were archived at the ADF&G office in Anchorage. The computer files were archived by ADF&G in the Anchorage and Bethel offices. Data were also loaded into the Arctic-Yukon-Kuskokwim (AYK) salmon database management system (Brannian et al. 2006a). Further details of sampling procedures can be found in DuBois and Molyneaux (2000).

Estimating Age, Sex, and Length Composition

ADF&G staff in Bethel and Anchorage aged scales and processed ASL data. DuBois and Molyneaux (2000) describe details. For each sampled species, 2 types of summary tables were generated from this process: one described the age and sex composition and the other described length statistics. These summary tables illustrated changes in the ASL composition throughout the season by first partitioning the season into temporal strata based on pulse sample dates and/or sample size requirements, and then applying the ASL composition of individual temporal samples to the corresponding temporal stratum, and finally summing the strata to generate the estimated ASL composition for the season. This procedure ensured that the ASL composition of the total annual escapement was weighted by the abundance of fish in the escapement rather than the abundance of fish in the samples. For example, if 6 pulse samples of chum salmon were collected, the season would be partitioned into 6 temporal strata whose dates were selected such that each stratum encompassed one pulse sample. Hence, a hypothetical sample of 200 chum salmon collected from 3 to 4 July would be used to estimate the ASL composition of the hypothetical escapement of 2,000 chum salmon that passed the weir during the temporal stratum that might extended from 1 to 7 July. This procedure would be repeated for each temporal stratum, and the estimated age and sex composition for the total annual escapement would be calculated as the sum of chum salmon in each stratum. In similar fashion, the estimated mean length composition for the total annual escapement would be calculated by weighting the mean lengths in each temporal stratum by the escapement of chum salmon that passed the weir during that stratum. Confidence intervals for estimates of length composition were constructed based on the method set forth by Thompson (1992, p.105).

Often in this document fish ages are reported using European notation. European notation is composed of two numerals separated by a decimal. The first numeral is the number of winters the juvenile has spent in freshwater and the second numeral is the number of winters it spent in the ocean (Groot and Margolis 1991). Total age of a fish is equal to the sum of these two numerals, plus 1 year to account for the winter when the egg was incubating in gravel. For example, a Chinook salmon described as age-1.4 is actually 6 years of age. European notation will be used throughout this document to represent specific age classes representing fish exhibiting a particular life history strategy. Total age will be used when discussing brood size because broods often consist of same age fish with different life history strategies. For example a brood of age-6 Chinook salmon may consist of age-1.4 and age-2.3 fish.

Visual Sex Determination

Sex was determined for every salmon passing upstream of the weir, including sockeye and pink salmon, through observation of sexually dimorphic characteristics. Visual determination of sex is possible due to advanced sexual dimorphism of each species. Females are obviously swollen and round behind the pectoral fins, have blunt (bullet-shaped) heads, and swim with wide and steady strokes. Males exhibit an exaggerated elongation of the kype, are streamlined and muscular in appearance, and swim with short and powerful strokes. Though some variation exists, these differences are applicable to all salmon species observed.

Sex compositions derived visually and through ASL were compared to assess possible biases in each method and to test the potential of visual sex determination in clear water tributaries. Each ASL stratum was considered independently, with the sex composition determined by ASL compared to the sex composition determined visually for the same time period.

WEATHER AND STREAM OBSERVATIONS

Water and air temperatures were manually measured each day at approximately 0730 and 1700 hours. Water temperature was determined by submerging a calibrated thermometer below the water surface until the temperature reading stabilized. Air temperature was obtained from a thermometer attached to an outside wall of the cabin in a shaded location. Temperature readings were recorded in a designated logbook, along with notations about wind direction, estimated wind speed, cloud cover, and precipitation. Daily precipitation was measured using a rain gauge calibrated in millimeters. These manual techniques are consistent with past years at this project. In 2006 and 2007, water temperature was also measured with a remote temperature logger located near mid-channel just upstream from the weir. The data logger was programmed to record temperature every hour during the operational period; however, in 2007 it was not installed until 18 July because it had been misplaced and was not found until mid July. Records were retrieved in the fall and compared to temperatures obtained using a thermometer.

Daily operations included monitoring river depth with a standardized staff gauge. The staff gauge consisted of a metal rod driven into the stream channel with a meter stick attached. The height of the water surface, as measured from the meter stick, represented the "stage" of the river in centimeters above an established datum plane. The staff gauge was calibrated to the datum plane by a semi-permanent benchmark to provide for consistent stage measurements between years. The benchmark consisted of a nail driven into the second step of a wooden staircase leading from the riverbank to the utility shed, which represents a measurement of 5 m above baseline and corresponds to the highest water level observed at the Kogrukluk River weir. Water stage was measured at approximately 0730 and 1700 hours.

RELATED FISHERIES PROJECTS

Kuskokwim River Chinook Salmon Run Reconstruction

The overall cost to initiate *Kuskokwim River Chinook Salmon Run Reconstruction* project (henceforth referred to as the "run reconstruction project") was relatively little because most of the infrastructure required to operate the project was already installed. The presence of weirs and other escapement monitoring projects was a critical component that satisfied the requirement for reliable escapement data. Nearly the entire network of stationary tracking stations and much of the tagging equipment was installed for previous and concurrent radiotelemetry-based projects, including *Inriver Abundance of Chinook Salmon in the Kuskokwim River* (Stuby 2007), *Kuskokwim River Sockeye Salmon Investigations* (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication), and *Assessment of Chinook, Chum, and Coho Salmon Escapements in the Holitna River Drainage Using Radiotelemetry* (Stroka and Brase 2004). Most of the tagging equipment was provided by these and a former project entitled *Kuskokwim River Salmon Mark-Recapture Project* (Pawluk et al. 2006). In subsequent text, these project names will be truncated to the following: “inriver abundance project”, “sockeye salmon investigations project”, “Holitna River telemetry project”, and “mark-recapture project”.

Objectives of the run reconstruction project included investigating the relationship between drainage-wide abundance estimates and known tributary escapements to derive a statistical model that would compute historical annual abundance estimates based on known tributary escapements. The run reconstruction project used data obtained from the inriver abundance project and most of the methods used by the latter were implemented into the experimental design of the former. The former inriver abundance project provided abundance estimates for each year between 2002 and 2006. In an effort to increase the power of the model and since the infrastructure was already in place, investigators decided to continue radio-tagging and anchor-tagging Chinook salmon in 2007 to achieve another annual abundance estimate. As with the inriver abundance project, radio transmitters were inserted into Chinook salmon with lengths greater than 450 mm caught near Kalskag (rkm 270) following methods described by Stuby (2007; Figure 1). Radio-tagged fish were detected by several tracking stations spread throughout the drainage and every weir upstream of the tagging locations was accompanied by a tracking station. Radio-tags are not visible when fish are viewed from the top, so every radio-tagged fish was fitted with an anchor tag that allowed weir crews to identify and trap radio-tagged fish for tag number recovery. Tag data recovered by weir crews supplemented, and sometimes verified, tracking station recovery information. This system of weirs and tracking stations allowed for: (1) the development of tagged-to-untagged ratios, (2) a means to test potential tagging bias, and (3) the development of annual abundance estimates for most of the drainage.

With the run reconstruction project, additional attention was given to the Aniak River drainage for which an annual abundance estimate had remained elusive. In 2006 and 2007, a weir and tracking station were installed together on an upper-river tributary of the Aniak River (Salmon River) to generate a tagged-to-untagged ratio assumed to be representative of the entire Aniak River drainage. Consequently, Aniak River abundance estimates are available for 2006 and 2007.

The location of the tracking station relative to the weir differed slightly at each weir location. At the Kogrukluk River weir site, the receiver station was placed about 100 m upstream of the weir. The known Chinook salmon passage at the weir, coupled with data collected from the receiver station, were used with similar data collected at other weir projects to develop estimates of the total Chinook salmon abundance upstream from the Kalskag tagging site.

Kuskokwim River Sockeye Salmon Investigations

The Kogrukluk River weir was used as a platform for the project entitled *Kuskokwim River Sockeye Salmon Investigations*. This project was designed to address critical knowledge gaps in the biology and ecology of Kuskokwim River sockeye salmon. Specifically, this project aimed to describe the location and relative abundance of sockeye salmon spawning aggregates, estimate stock-specific run-timing in the main stem of the Kuskokwim River, describe and compare habitat use and seasonal migration patterns of river-type and lake-type juveniles, and describe and compare smolt size and growth among tributaries and habitat types. These goals were addressed by conducting a 2-sample mark–recapture study within the upper Kuskokwim River drainage above Kalskag and conducting juvenile studies within various habitat types throughout the Holitna drainage.

Similar to Chinook salmon radio-tagging efforts, radio transmitters were inserted into sockeye salmon caught near Kalskag. Radio-tagged fish were also equipped with an anchor tag to assess incidences of tag loss. A combination of radio receiver stations located throughout the upper Kuskokwim River drainage (the same receiver stations used for the Chinook project) and aerial surveys was used to monitor the movement of tagged fish. In 2006, juvenile salmon were sampled from various habitat types throughout the Holitna drainage using standard seining techniques. The known sockeye salmon passage at the weir projects located throughout the upper drainage, coupled with data collected from tracking efforts, was used to address distribution, abundance, and run-timing of spawning aggregates. Data from seining efforts were used to address habitat use, out migration timing, and variation in size and growth of juvenile sockeye salmon.

In support of this project, the Kogrukluk River weir crew was instructed to opportunistically sample sockeye salmon for ASL information. The sampling of sockeye salmon was not a principal objective of the weir project itself, and the success of the sampling effort is not determined by the achievement of confidence intervals or temporal distribution of the sampling collection as described in Objective 2 for other species. ASL data were obtained from sockeye salmon primarily to support *Kuskokwim River Sockeye Salmon Investigations*; however, since these data also enable historical comparisons, some aspects of the data will be discussed in this report.

Genetic Sample Collections

In 2007, the Kogrukluk River weir was used as a platform to collect genetic tissue from pink salmon and Dolly Varden. The collection of pink salmon genetic tissue was not in conjunction with any specific research project. Pink salmon samples were sent to the ADF&G genetics lab in Anchorage for storage and processing. The collection of Dolly Varden genetic tissue was in support of a USFWS project entitled *Baseline development for Dolly Varden in southwestern Alaska*. Dolly Varden samples were sent to the USFWS conservation genetics lab in Anchorage for storage and processing.

The Kogrukluk River weir and crew facilitated these efforts by capturing pink salmon and Dolly Varden, collecting and preserving the appropriate genetic tissue for each species, and visually determining sex and measuring total length of Dolly Varden. Samples were sent to ADF&G and USFWS at the end of the season. Sampling efforts were conducted on an opportunistic basis and employed any capture method possible.

RESULTS

ESCAPEMENT MONITORING

The operational period in the 2007 Kogrukluk River weir field season was 26 June through 23 September. Installation of the weir began on 22 June and the weir was fully operational by 1230 hours on 26 June. The weir was operated intermittently until it was removed for the season on 24 September.

Between 26 June and 24 September the weir suffered 5 inoperable periods resulting from high water levels and deleterious debris loads. The first occurred between 11 and 17 July, the second occurred between 20 and 22 July, the third occurred between 4 and 7 August, the fourth occurred between 9 and 15 September, and the fifth occurred between 19 and 21 September. To prevent structural damage that would impair future weir operation, the crew dismantled parts of the weir once water level or debris load exceeded a safe level.

Chinook Salmon

Total annual Chinook salmon escapement upstream of the Kogrukluk River weir in 2007 was 13,029 fish, which includes an estimated 6,106 fish (46.9% of the total run) that passed during inoperable periods. The first Chinook salmon was observed on 27 June, daily passage peaked at 754 fish on 19 July, and the last Chinook salmon was observed on 6 September (Table 1). The median passage date was 18 July and the central 50% of the passage occurred between 13 and 23 July.

Chum Salmon

Total annual chum salmon escapement upstream of the Kogrukluk River weir in 2007 was 49,505 fish, which includes an estimated 18,084 fish (36.5% of the total run) that passed during inoperable periods. The first chum salmon was observed on 27 June and daily passage peaked at 2,921 fish on 18 July (Table 1). Chum salmon were observed every day the weir was operational, but daily passage was very low during the last 2 weeks of operation. The median passage date was 19 July and the central 50% of the passage occurred between 14 and 27 July.

Coho Salmon

Total annual coho salmon escapement upstream of the Kogrukluk River weir in 2007 was 27,033 fish, which includes an estimated 3,237 fish (12.0% of the total run) that passed during inoperable periods. The first coho salmon was observed on 21 July and daily passage peaked at 1,698 fish on 25 August (Table 1). Daily passage during the last few days of weir operation in 2007 was over 100 fish per day. The median passage date was 29 August and the central 50% of the passage occurred between 23 August and 5 September.

Sockeye Salmon

Total annual sockeye salmon escapement upstream of the Kogrukluk River weir in 2007 was 16,525 fish, which includes an estimated 6,521 fish (39.5% of the total run) estimated to have passed during inoperable periods. The first sockeye salmon was observed on 29 June, daily passage peaked at 1,074 fish on 26 July, and the last sockeye salmon was observed on 16 September (Table 1). The median passage date was 22 July and the central 50% of the passage occurred between 17 and 28 July.

Pink Salmon

Observed pink salmon escapement upstream of the Kogrukluk River weir in 2007 was 32 fish, which does not include estimates from inoperable periods (Appendix A1). Passage estimates for inoperable periods are not considered accurate and will not be discussed in detail in this report. The occurrences of sporadic operational days coupled with the extremely low numbers of observed individuals confound attempts to extrapolate missed passage. Furthermore, the number of individuals observed passing the weir when it was operational is certainly an underestimate of the actual escapement that occurred during the same time because pink salmon are small enough to pass between the pickets uncounted. Nevertheless, pink salmon were observed passing upstream of the weir from 17 July to 30 July.

Other Species

Several other species are routinely observed passing upstream and downstream of the weir by crew members during normal salmon enumeration routines. Other species observed passing upstream of the Kogrukluk River weir during the 2007 field season include 3,649 char (*Salvelinus spp.*) and 94 whitefish (*Coregonus sp.*; Appendix A1). Arctic grayling (*Thymallus arcticus*) and northern pike (*Esox lucius*) were also observed but total counts were not recorded. For a complete listing of fish species in the area, see Baxter[5].

Carcasses

A total of 13,286 salmon carcasses were recovered from the Kogrukluk River weir (Appendix B1), or 12.5% of the total annual escapement of all Pacific salmon species. A total of 1,928 Chinook salmon carcasses were recovered (14.8% of the annual escapement) from 24 July through 7 September. From 2 July through 18 September, 9,055 chum salmon carcasses were recovered, comprising 18.3% of the annual escapement. The 2,257 sockeye salmon carcasses recovered in 2007 comprised 13.7% of the observed annual escapement and were collected from 26 July through 16 September. Weir removal occurs well before the bulk of coho salmon carcasses return downstream resulting in only 30 coho salmon carcasses being recovered (0.1% of the annual escapement) from 29 August through 18 September. A total of 16 pink salmon carcasses were recovered (50% of the observed annual escapement) from 19 July through 20 August. Other fish species recovered from the weir include Arctic grayling, char, northern pike, whitefish and burbot.

Crew did not attempt to count carcasses by sex in 2007 because estimating the sex composition of upstream escapement from carcass counts is not reliable. Generally, sexing the carcasses yields female salmon percentages that are considerably lower than the percentage determined from ASL sampling (Costello et al. 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). The additional effort and processing time required to count carcasses by sex is not justified given the limited utility of the data.

AGE, SEX, AND LENGTH COMPOSITION

Chinook Salmon

Chinook salmon ASL sampling at the Kogrukluk River weir was conducted on an opportunistic basis from 2 July to 31 July, resulting in a total sample of 330 fish. Age, sex, and length were successfully determined for 289 fish (87.6% of the total sample) or 2.2% of the annual escapement (Table 2). The total annual escapement was partitioned into 3 temporal strata based on sample size the temporal distribution of the sampling effort. Sample sizes of the first, second, and third strata were 97, 104, and 88 fish, respectively (Table 2). The total-season sample size of 289 fish was greater than the 180-fish sample necessary to achieve the confidence interval width of 0.20 (Bromaghin 1993); however, sample sizes per pulse were not adequate to achieve the desired confidence interval for the individual strata. Adjusting for the known population size made no difference (i.e. finite population correction: Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication). Although objectives were not fully met, data are sufficient to reasonably investigate intra-annual trends and can help define historical trends.

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[5] Baxter, R. Holitna River salmon studies, 1977. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Escapement Report No. 13, Anchorage.

Age Composition

The Chinook salmon escapement past the weir was nearly uniformly represented by 3 age classes (Table 2). Combined, these 3 age classes comprised 97% of the total annual escapement. Furthermore, each age class comprised about the same percentage of the total run: age-1.2 (4 year old) fish comprised 32.3%, age-1.3 (5 year old) fish comprised 33.0%, and age-1.4 (6 year old) fish comprised 31.7%. Age-1.5 fish were relatively few and comprised only 2.9% of annual escapement. No other age classes were sampled although they are known to occur in some systems. All age-1.2 fish and most age-1.3 fish were males whereas most age-1.4 and age-1.5 fish were females.

Temporal variations in age class percentages were observed. The percentages of age-1.2 and age-1.3 fish continually decreased from the first stratum to the last whereas the percentage of age-1.4 fish generally increased (Figure 4). Consequently, the first stratum was dominated by age-1.3 fish (43.3%) whereas the second and third strata were independently dominated by age-1.4 fish (38.5% and 37.5%, respectively).

Sex Composition

The ratio of males to females in the Chinook salmon escapement past the weir was approximately 5:2 (Table 2). Female Chinook salmon comprised 28.4% of the total annual escapement based on weighted ASL samples. The percentage of females steadily increased over the course of the run, comprising 13.4 % in the first stratum, 34.6% in the second stratum, and 39.8% in the third stratum (Figure 5). This occurrence is largely influenced by the relative abundance of male-dominated age-1.2 fish, which was highest in the first stratum and lowest during the last. The majority of female Chinook salmon were 6 years old (68.5%) whereas the majority of males were 4 years old (45.2%) of 5 years old (36.7%).

The method of visually identifying the sex of every passing Chinook salmon yielded a sex ratio similar to that derived from ASL sampling. Based on this method, female Chinook salmon comprised 25.1% of the annual escapement (Figure 6). Stratification of male and female passage counts into the same temporal strata used in the process of estimating intra-annual trends in ASL composition yielded per-strata sex ratios that generally mimicked those derived from ASL sampling. Determined through regular passage counts, females comprised 15.3%, 26.2%, and 34.5% of total Chinook salmon escapement during the first, second, and third stratum, respectively.

Length Composition

Analysis of length composition revealed partitioning by sex and age class. The length of female Chinook salmon ranged from 723 to 969 mm, and males ranged from 436 to 998 mm. In the 2 age classes that contained considerable numbers of both males and females (ages 1.3 and 1.4), female Chinook salmon were larger at age than males and average length increased with age for both females and males (Figure 7). Average length of age-1.3 females was 788 mm while the average length of age-1.4 females was 863 mm and the average length of age-1.5 females was 851 mm. Average lengths for male age-1.2, -1.3, -1.4, and -1.5 Chinook salmon were 546 mm, 685 mm, 781 mm, and 804 mm, respectively. Considering the variation within an age class, average lengths-at-age varied little during the run for both male and female Chinook salmon (Table 3; Figure 8).

Chum Salmon

Chum salmon ASL sampling at the Kogrukluk River weir was conducted on an opportunistic basis from 2 July to 31 July, resulting in a total sample of 764 fish. Age, sex, and length were successfully determined for 640 fish (83.8% of the total sample) or 1.3% of the total annual escapement (Table 4). The total annual escapement was partitioned into 4 temporal strata based on the temporal distribution of sampling effort. Sample sizes were 187, 196, 173 and 84 aged fish for the first, second, third, and fourth strata, respectively (Table 4).

Objective 2, as it pertains to chum salmon, was achieved in 2007. Postseason analysis revealed the total sample size and distribution was adequate for estimating annual age composition of chum salmon escapement past the weir. The stipulation that 3 pulse samples must be collected, one from each third of the run, was achieved because 4 pulse samples were collected and were well distributed. Sample sizes in each of the first 3 pulse samples, which were positioned at approximately 2%, 28%, and 69% of the run (respectively), were adequate to achieve the desired confidence interval width of 0.20. Unfortunately, the last pulse sample that occurred at approximately 86% of the run was too small to achieve the desired confidence interval width; however, this pulse sample was considered supplemental and did not affect whether or not the objective was achieved. The collection of 4 pulse samples improves investigators' ability to interpret intra-annual trends and data from the fourth pulse sample will be graphed along with others despite the relatively small sample size.

Age Composition

The chum salmon escapement past the weir was largely represented by 2 age classes (Table 4). Combined, these 2 age classes comprised over 94% of the annual escapement. Age-0.3 was the most abundant age class (59.2%), followed by age-0.4 (34.9%), age-0.5 (3.0%), and age-0.2 (2.9%). All assumed age/sex categories were found in 2007; however, no age-0.2 male chum salmon were sampled in the first 3 strata and no age-0.5 fish of either sex were sampled during the last stratum. Most age-0.2 fish were females whereas age classes 0.3, 0.4, and 0.5 were predominantly male.

Relative age composition changed considerably over the course of the run. The percentage of age-0.3 chum salmon tended to increase during the run while the percentages of age-0.4 and age-0.5 chum salmon tended to decrease (Figure 9). Little change occurred among age-0.2 chum salmon during the first 3 strata, but their percentage increased considerably during the last. These trends in age class percentages appeared to weaken with a rebound in the percentage of age-0.4 chum salmon during the last stratum when they were expected to be lowest (Figure 9). However, the sample size of the last pulse sample was considerably smaller than the others and may indicate that the difference may not be significant.

Sex Composition

Based on ASL sampling, the ratio of males to females in the chum salmon escapement past the weir was approximately 3:2 (Table 4). Female chum salmon comprised 37.6% of the total annual escapement based on weighted ASL samples. Sex composition varied slightly during the run but no consistent trends were apparent (Figure 5). The percentage of females was lowest during the first strata (29.9%) and highest during the second (40.8%). Both the male and female escapement was dominated by age-0.3 individuals (57.9% for males, 61.5% for females).

The method of visually identifying the sex of every passing chum salmon yielded a sex ratio similar to that derived from ASL sampling. Based on this method, female chum salmon comprised 36.6% of the annual escapement (Figure 6). Stratification of male and female passage counts into the same temporal strata used in the process of estimating intra-annual trends in ASL composition yielded per-strata sex ratios similar to those derived from ASL sampling. Determined through regular passage counts, females comprised 37.5%, 35.7%, 33.0%, and 43.5% of total chum salmon escapement during the first, second, and third stratum, respectively.

Length Composition

Analysis of length composition revealed partitioning by sex and age class. The length of female chum salmon ranged from 481 to 606 mm and males ranged from 482 to 680 mm. Males were generally larger at age than females, and average length generally increased with age for males but not for females (Figure 7). Average lengths for female age-0.2, -0.3, -0.4, and -0.5 chum salmon were 511, 542, 548, and 570 mm, respectively. Average length for male age-0.3, -0.4, and -0.5 chum salmon was 553, 570, and 586 mm, respectively. Two male chum salmon of the 0.2 age class were sampled and had lengths of 494 and 535 mm. For both males and females, average length-at-age varied little during the run (Table 5; Figure 10).

Coho Salmon

Coho salmon ASL sampling at the Kogrukluk River weir was conducted on an opportunistic basis from 20 August to 18 September, resulting in a total sample of 473 fish. Age, sex, and length were successfully determined for 394 fish (83.3% of the total sample) or 1.5% of the annual escapement (Table 6). The run was partitioned into 3 temporal strata based on the temporal distribution of sampling effort, with sample sizes of 135, 147, and 112 aged fish per stratum, respectively. The total-season sample size of 394 fish was greater than the 180-fish sample necessary to achieve the confidence interval width of 0.20 (Bromaghin 1993); however, sample sizes per pulse were not adequate to achieve the desired confidence interval for the individual strata, after adjusting for the known population size (i.e. finite population correction: Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication). Although objectives were not achieved, data are sufficient to reasonably investigate intra-annual trends and can help define historical trends.

Age Composition

The coho salmon escapement past the weir was dominated by age-2.1 individuals, which comprised 90.7% of total escapement (Table 6). Age-3.1 fish comprised 5.8% of the escapement and age-1.1 fish comprised 3.5% of the escapement. No individuals from other age classes were found in the sample. Most age-1.1 and age-2.1 fish were males whereas most age-3.1 fish were females.

Slight variations in age class percentage occurred over the course of the run in 2007, but no consistent trends were observed (Figure 11). The percentage of age-1.1 fish was highest in the first stratum and lowest in the last, the percentage of age-2.1 fish was highest in the middle stratum and lowest in the last, and the percentage of age-3.1 fish was highest in the last stratum and lowest in the middle.

Sex Composition

The ratio of males to females in the coho salmon escapement past the weir was approximately 5:4 (Table 6). Females comprised 44.6% of the total annual escapement based on weighted ASL samples. The percentage of females steadily increased over the course of the run, comprising 28.1% in the first stratum, 51.7% in the second stratum, and 58.9% in the last stratum (Figure 5). This occurrence is influenced by the higher abundances of both age-1.1 and age-2.1 male coho salmon in the first stratum.

The method of visually identifying the sex of every passing coho salmon yielded a sex ratio similar to that derived from ASL sampling. Based on this method, female coho salmon comprised 46.1% of the annual escapement (Figure 6). Stratification of male and female passage counts into the same temporal strata used in the process of estimating intra-annual trends in ASL composition yielded per-strata sex ratios that generally mimicked those derived from ASL sampling. Determined through regular passage counts, females comprised 41.2%, 47.5%, and 57.2% of total coho salmon escapement during the first, second, and third stratum, respectively.

Length Composition

Analysis of length composition revealed partitioning by sex and age class (Table 7). The length of female coho salmon ranged from 402 to 651 mm, and males ranged from 402 to 644 mm. Female fish tended to be larger than males of the same age. Figure 7 illustrates that the difference was significant for age-2.1 fish. Average length tended to increase with age for females but not for males; however, small sample sizes may discredit this observation. Average lengths for age-1.1, -2.1, and -3.1 female fish were 549, 551, and 553 mm, respectively. Average lengths for age-1.1, -2.1, and -3.1 male fish were 527, 536, and 522 mm, respectively. Average length at age varied little during the run (Figure 12).

Sockeye Salmon

Sockeye salmon ASL sampling at the Kogrukluk River weir was conducted on an opportunistic basis from 23 July to 2 August, resulting in a total sample of 206 fish. Age, sex, and length were determined for 167 fish (81.1% of the total sample) or 0.7% of the total annual escapement (A. R. Brodersen, Commercial Fisheries Technician, ADF&G, Anchorage; personal communication). Results are summarized in Tables 8 and 9.

Since samples were not collected in pulses, and the entire sample was collected within 11 consecutive days, the annual sockeye salmon run was not partitioned into temporal strata. The data do not allow investigation of intra-annual trends, but the number of fish sampled was more than adequate to estimate total run ASL composition. However, data are limited in that all of the sampling effort occurred within the last 50% of the run as it passed the weir. Thus, the number of samples was sufficient to reasonably estimate ASL composition, but the temporal distribution of the sample collection was deficient. Furthermore, investigators have little confidence in the saltwater component (numeral after the decimal) of the ages due to the high occurrence of scale absorption known to occur among Kogrukluk River sockeye salmon. Therefore, age composition and related length statistics will not be discussed in detail.

Sex and Length Composition

Female sockeye salmon comprised 39.5% of the total annual escapement based on weighted ASL samples (Table 8). The sex female percentage resulting from the visual method was slightly higher. Based on this method female sockeye salmon comprised 47.7% of the annual escapement. Male sockeye salmon tended to be larger than females. Males ranged from 516 to 631 mm whereas females ranged from 480 to 582 mm (Table 9).

WEATHER AND STREAM OBSERVATIONS

A total of 189 complete observations of weather and stream conditions were recorded between 6 June and 25 September (Appendix C1). Based on twice-daily thermometer observations, water temperature at the weir ranged from 6.0° to 14.0°C, with an average water temperature of 10.3°C. Based on hourly data logger readings, daily average water temperature ranged from 5.8°C to 14.9°C, with an average daily temperature of 10.0°C (Appendix C2). Air temperature at the weir ranged from 3° to 28°C, with an average air temperature of 13.3°C (Appendix C1). A total of 253.2 mm of precipitation was recorded throughout the season. River stage ranged from 278 to 359 cm, with an average of 299 cm (Appendix C1).

RELATED FISHERIES PROJECTS

Kuskokwim River Chinook Salmon Run Reconstruction

Telemetry data from the tracking station at the Kogrukluk River weir along with telemetry data from aerial tracking efforts and tag passage data through the weir revealed that 44 tagged Chinook salmon passed upstream of the weir site.

The 2007 estimates of Chinook salmon abundance provided by this study are preliminary at the time of writing; however, they are probably near the final values and sufficient for discussion here. Estimates resulting from this study indicate that 121,370 Chinook salmon greater than 450 mm in length (SE = 13,027; 95% CI = 95,837–146,904) migrated upstream of Kalskag and a total of 105,832 Chinook salmon greater than 450 mm in length (SE = 12,288; 95% CI = 81,747–129,916) migrated upstream of the Aniak River confluence (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication). According to these estimates, the Kogrukluk River stock represented 10.7% of total abundance upstream of Kalskag and 12.3% of the abundance upstream of the Aniak River confluence.

Kuskokwim River Sockeye Salmon Investigations

A total of 48 radio-tagged and 21 anchor-tagged sockeye salmon were observed/detected passing the Kogrukluk River weir and receiver station in 2007. Radio-tagged sockeye salmon were tracked to tributaries throughout the Kuskokwim River basin using 18 ground-based tracking stations, and 2 aerial tracking surveys conducted in July and August. Of the 488 radio tags deployed, 398 (81%) successfully resumed upstream migration, and 378 (77%) were successfully tracked to tributary streams. Of the 697 sockeye salmon fitted with anchor-tagged sockeye salmon, 48 were found in major tributaries (either at escapement monitoring projects or volunteer recaptures) upstream from the tagging location. Radio-tagged sockeye salmon were detected in most major drainages between Kalskag and the Stony River drainage. Large aggregates were observed in the Aniak, Holitna, Hoholitna, and Stony River drainages, and 4 were observed in the Holokuk River. The highest concentrations were observed throughout the Holitna River. Complete results of this project can be obtained from Gilk (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).

Genetic Sample Collections

Approximately 10 pink salmon and 77 Dolly Varden genetic samples were collected from the Kogrukluk River weir in 2006. The pink salmon genetic samples were preserved and stored by ADF&G staff in anchorage. Information regarding the collection and processing of the Dolly Varden genetic samples can be obtained from Lisac (M. J. Lisac, Fisheries Biologist, USFWS Togiak National Wildlife Refuge, Dillingham; personal communication).

DISCUSSION

ESCAPEMENT MONITORING

In 2007, the Kogrukluk River weir operated from 26 June to 23 September, and these dates and duration were sufficient to properly encompass the run timing of all Kogrukluk River salmon stocks. This conclusion was supported by 3 observations. First, in 2007, operations of the Kogrukluk River weir were similar in duration and timing to the historical average (Figure 13). Second, salmon passage was low to moderate for several days following weir installation (Table 1), indicating that relatively few fish escaped upstream of the weir site prior to installation. Third, despite tagging efforts having begun at the Kalskag fish wheels on 1 June (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication), no radio-tagged salmon were detected by the nearby receiver station prior to the weir being installed; therefore, it is unlikely that Chinook salmon were present in the area in great abundance.

Although the weir operational period was sufficient to collect escapement data, weir operations in 2007 were considered moderately successful because of several inoperable periods caused by high water conditions and unmanageable debris loads that occurred throughout the season. Many of these inoperable periods fell on dates when passage of Chinook, chum, and/or sockeye salmon has historically been high, so total annual escapement values for these species were not as reliable as in past years. Nearly 47% of the Chinook, 37% of the chum, and 40% of the sockeye salmon escapements were interpolated for inoperable periods (Appendix D1). The weir fared much better during the coho salmon run, for which only 12% of the run was interpolated for inoperable periods in. Despite these obvious limitations, reported annual escapements of these species are considered reasonable approximations of actual annual escapement because most of the inoperable periods lasted only a few days and the weir resumed successful operations between them. Combined with historical data, escapement values for 2007 will provide an important reference for constructing future estimates, models, and management initiatives.

The reported escapement value for pink salmon is accompanied by an additional factor that further reduces its reliability. In terms of the spacing between the pickets, this weir and most others in the Kuskokwim River drainage are not designed to enumerate pink salmon. In the past, pink salmon have been observed passing between the pickets. This issue was partially remedied in 2005 when the weir structure was modified with new components that reduced picket spacing (Jasper and Molyneaux 2007); however, even with these improvements, investigators are not certain that pink salmon are fully restrained when passage gates are shut. All reported escapement values including days the weir is fully operational under-represent true daily passage. It is important to recognize these caveats when using pink salmon escapement data from this project.

Our determinations of annual escapements revealed above-average abundances of Chinook, chum, sockeye, and coho salmon. Escapements of those species for which an escapement goal has been developed (Chinook, chum, and coho) were within the escapement goal range and near the upper boundary (Figures 14 and 15). During the 2–3 years immediately preceding 2007, annual escapements of Chinook and chum salmon exceeded the upper boundary of the escapement goal range and sockeye salmon have remained well above the historical average (Jasper and Molyneaux 2007; Liller et al. 2008; Shelden et al. 2005). Annual coho escapements in recent years have generally been within or above the escapement goal range since 2000, except in 2003 when the escapement was anomalously high (Shelden et al. 2004). Coho escapements at Kogrukluk River weir have only been below the lower boundary of the escapement goal 3 times in the past 17 years (Figure 15). This recent pattern of strong salmon escapement has been spatially consistent throughout the Kuskokwim River drainage, as evidenced by several other weir projects and escapement indices operated in the area (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*).

The increased escapement of most Pacific salmon species throughout the Kuskokwim River drainage in recent years may be partially explained by more conservative management of the commercial fishery, which may have affected the parent populations of the 2007 escapement. After the BOF initially classified Kuskokwim River Chinook and chum salmon as "stocks of yield concern" in 2000, fishery managers implemented several changes to mitigate effects of commercial fishing on these stocks (Bergstrom and Whitmore 2004). The prohibition of commercial fishing in districts W-1 and W-2 in June and July (or until managers had sufficient evidence that escapement goals would be achieved) was one initiative to curb harvest pressure, and improved abundances of Chinook and chum salmon in recent years led to the rescission of the stocks of yield concern designation in February 2007 (Linderman and Bergstrom 2006). The occurrence of relatively high escapements in 2007 supports this decision. Fisheries managers are more amenable to June and July District W-1 openings, but there are no plans to open District W-2 because processors have shown little interest in buying from fishers in this district.

In 2007, District W-1 remained closed to commercial fishing in June and July. The relatively low exploitation in 2007 was due to a lack of commercial market and processor interest that resulted in the commercial fishery remaining closed throughout all of June and July, and was not a consequence of low abundance, (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). Another factor influencing the low harvests reported in recent years has been the timing of the commercial fishery (June and/or July), which maximizes the number of chum salmon harvested and reduces more valuable catches of Chinook and sockeye salmon, resulting in depressed ex-vessel prices driven by low market demand and processor transportation costs.

Even when commercial fishing is permitted, species-specific commercial fishing pressure varies due to variation in fish abundance, market value, and processing capabilities. For example, in 2007 District W-1 remained closed until 1 August and District W-2 remained closed for the entire season due to a lack of a commercial market. These prolonged closures severely restricted the harvest of Chinook and chum salmon. Coho salmon endured moderate commercial fishing pressure in 2007 during 12 coho salmon-directed commercial openings that occurred in District W-1 between 1 and 24 August (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).

For Chinook salmon, the subsistence fishery has always had a greater impact on escapement than has the commercial fishery, and, in recent years, this has been true of chum and sockeye salmon as well (Smith et al. *In prep*). Species-specific subsistence fishing pressure within the Kuskokwim River varies greatly, and Chinook and chum salmon are usually the more heavily targeted. The decision not to implement a subsistence schedule in 2007 was influenced by several factors: first, returns of Chinook and chum salmon were expected to be above average; second, the BOF recently discontinued the stock of concern designation; and third, the schedule imposed on fishers between 2001 and 2006 proved ineffective at improving the temporal distribution of harvest effort (Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication). Throughout the 2007 season, subsistence fishing was permitted continuously with the exception of closed periods surrounding commercial fishing periods. As a result, the subsistence fishing harvest probably noticeably detracted from tributary escapements, including those to the Kogrukluk River. Historically, subsistence harvests have been relatively consistent from year to year for all species (Smith et al. *In prep*), despite considerable variation in abundance and escapements.

In the early 1980s fisheries management shifted from a strategy that emphasized guideline harvest levels to one emphasizing escapement, which was probably to the benefit of Kuskokwim River salmon populations (Buklis 1993). As a result, species-specific escapement goals were established for tributaries with sufficient historical baseline information, one of which was the Kogrukluk River. Now termed "sustainable escapement goals" or "SEGs", the escapement goals established for Kuskokwim River tributaries are levels of escapement, indicated by an index or an escapement estimate, which are known to provide for sustained yield over a 5–10 year period (Brannian et al. 2006b). The first formal escapement goals, expressed as thresholds, were established at the Kogrukluk River weir in 1983 for Chinook (10,000), chum (20,000), sockeye (2,000), and coho salmon (20,000). In 1984, escapement goals were increased to 30,000 for chum and 25,000 for coho salmon. In January 2004, Kogrukluk River escapement goals were revised again and have since been expressed as ranges (ADF&G 2004). These revised escapement goals have been in effect since the 2005 season. For Chinook salmon the current SEG range is 5,300 to 14,000 fish, for chum salmon it is 15,000 to 49,000 fish, and for coho salmon it is 13,000 to 28,000 fish (Brannian et al. 2006b). Throughout most of the 1980s and into the 1990s sockeye salmon had an escapement goal as well; however, this goal was discontinued around 1995 because at that time sockeye salmon enumeration was considered ancillary and sockeye catch considered incidental (Burkey et al. 1997).

Chinook Salmon

Abundance

The timing of the inoperable periods that occurred in 2007 affected Chinook salmon more than any other species. Most inoperable days coincided with dates historically characterized by high Chinook salmon passage, which reduces investigators' confidence that reported annual escapement reflects actual escapement. Consequently, the reported 2007 escapement of Chinook salmon is not as reliable compared to most recent years. Nevertheless, it is still a valuable indicator of run condition and is adequate to reasonably investigate inter-annual differences and historical trends.

Considerable variation in abundance of Chinook salmon has been observed throughout the 32 year history of escapement monitoring at the Kogrukluk River (Figure 14). Escapement in 2007 was near the upper boundary (14,000 fish) of the current SEG range, but was a considerable decrease from 2005 and 2006 (Jasper and Molyneaux 2007; Liller et al. 2008). Chinook salmon escapements to the Kogrukluk River have exhibited a distinct sinusoidal pattern of increase and decrease throughout most of project history (Figure 14), perhaps resulting from climatic shifts such as El Nino/La Nina events. The "crest" observed in recent years was reflective of similar periods that occurred in the early 1980s and mid 1990s. The regularity of this sinusoidal trend has predictive potential and suggests 2008 escapement may be lower than 2007.

This persistent trend reveals that high returns from brood years with low abundance and low returns from brood years with high abundance, though counterintuitive, are not uncommon. For example, the record-high escapements observed at the Kogrukluk River weir in 2004, 2005, and 2006 consisted of the return from parent years of low abundance (1999 and 2000). Appendix E1 is a brood table generated from the available Kogrukluk River data, which can be used to assess the above mentioned sibling relationships and cohort strength, but it does not account for the fraction of Kogrukluk River bound fish taken in the harvest that occurs downstream of the weir..

Overall, Kuskokwim River Chinook salmon escapement was considered above average in 2007, although most projects reported a decrease in Chinook salmon escapement from 2006 and, at many, annual escapements have been declining steadily since 2005 (Figure 16; Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). Nevertheless, the Kuskokwim River drainage-wide index for 2007 is the fourth highest on record (Figure 16). Estimates of drainage-wide abundance of Chinook salmon provided by radio-tagging data parallel trends seen in the drainage-wide index and at most monitoring projects. An estimated 105,832 Chinook salmon escaped upstream of the Aniak River confluence in 2007 (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication), which was lower than the past 3 years but higher than 2002 (100,733) and 2003 (103,161) (Stuby 2007). This pattern of abundance for the entire upper drainage is mirrored in the observed annual escapements at each of the upper river weir projects. The proportion of the total drainage wide abundance above Aniak escaping to the Kogrukluk River (approximately 12% in 2007) is greater than all other upriver escapement projects combined. George River Chinook salmon generally represent 3% of the total upriver abundance (Thalhauser et al. *In prep*), while Tatlawiksuk and Takotna River weirs represent approximately 2% and 0.3% respectively (Costello et al. 2008; Stewart et al. 2008). The annual proportion of the total run above Aniak monitored by each upriver weir project has been fairly consistent. These relationships suggest that the Kogrukluk, George, Tatlawiksuk, and Takotna River weirs, singly and in concert, provide a reasonable index of abundance of Chinook salmon within the mid to upper Kuskokwim drainage.

The most notable disparities in annual abundances occurred at the Tuluksak River weir (lower river) where 2007 escapement was the lowest on record (Figure 16; Plumb and Harper 2008) and at the George River weir (mid river) where escapement in 2007 exceeded escapements from 2005 and 2006 (Thalhauser et al. *In prep*). Regardless of how they differ between this year and last, Chinook salmon escapement in 2007 was higher than in 1999 and 2000 at projects that were operated in those years (the Tuluksak River weir was not operated in 1999 or 2000). It was the low escapements in 1999 and 2000 that motivated the BOF decision to designate Kuskokwim River Chinook and chum salmon as stocks of yield concern.

By limiting exploitation, the continuous closure of the commercial fishery in District W-1 until 1 August likely increased annual escapements of Kogrukluk River and other Kuskokwim River Chinook salmon stocks. The only harvest of Chinook salmon that did occur in the commercial fishery was taken during coho salmon-directed commercial openings in August. The harvest of 179 Chinook salmon during the coho salmon-directed commercial openings (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication) had virtually no effect on tributary escapements. Regardless of whether the proportion of Kogrukluk River fish in the commercial harvest was high or low, the commercial harvest did not significantly impact Kogrukluk River Chinook salmon.

Contrary to the commercial fishery, the effect of the subsistence fishery on individual Kuskokwim River Chinook salmon stocks was probably significant. The total subsistence harvest for 2007 has not yet been estimated; however, the annual subsistence harvest of Chinook salmon has remained relatively constant through history, despite varying abundance, so the most recent 10 year average (1997–2006) of 72,277 fish probably reasonably approximates the 2007 harvest (Smith et al. *In prep*). The subsistence harvest and the relatively small incidental commercial harvest of 179 fish add to an approximate harvest of less than 73,000 in 2007 (Smith et al. *In prep*). When compared to the estimated inriver abundance of 121,370 Chinook salmon above Kalskag and the 105,832 fish above the Aniak River (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication), it is obvious that, in terms of size, the subsistence harvest represents a significant component of the total run. The region of the Kuskokwim River above Aniak experiences relatively limited harvest of Chinook salmon (D. Koster, Research Analyst, ADF&G, Anchorage; personal communication); consequently, estimates of abundance above the Aniak are a reasonable estimate of total escapement to this region of the Kuskokwim drainage.

Run Timing at Weir

The 2007 Chinook salmon run at the Kogrukluk River weir was one of the latest on record (Figure 17). The central 50% passage in 2007 occurred from 13 to 23 July, compared to the historical average of 7 to 17 July. The 2007 median passage date of 18 July was the second latest on record for the Kogrukluk River weir. The earliest median passage date at the project is 7 July (1981 and 1996), the average date is 12 July, and the latest date is 20 July (1999) (Figure 17). All other Kuskokwim River escapement monitoring projects exhibited relatively late run timing in 2007 while run durations were average (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*).

Chum Salmon

Abundance

The timing of inoperable periods in 2007 significantly affected escapement counts of chum salmon. Most inoperable days coincided with dates historically characterized by high chum salmon passage, which reduces investigators' confidence that reported annual escapement reflects actual escapement. Consequently, the reported 2007 escapement of chum salmon is not as reliable compared to most recent years. Nevertheless, it is still a valuable indicator of run condition and is adequate to reasonably investigate inter-annual differences and historical trends.

Considerable variation in abundance of chum salmon has been observed throughout the 32 year history of escapement monitoring for this project (Figure 14). Although annual chum salmon escapement in 2007 was far below the unprecedented escapements in 2005 and 2006 (Jasper and Molyneaux 2007; Liller et al. 2008), it was still the sixth highest on record and just surpassed the upper limit of the SEG range. No distinct pattern is obvious for Kogrukluk River chum salmon.

Overall, Kuskokwim River chum salmon escapement was considered high in 2007. Where chum salmon escapement goals have been developed in the Kuskokwim drainage (Kogrukluk River weir and Aniak River sonar), the chum salmon escapement in 2007 exceeded current escapement goal ranges (Figure 18; McEwen *In prep*). Aniak River sonar and Kogrukluk River weir have shown similar trends in chum salmon escapement in recent years, both having shown record highs in 2005 and escapements only slightly lower in 2006. Escapements in 2007 at both projects were considerably below both 2005 and 2006 (Figure 18; McEwen *In prep*). Every monitoring project in the Kuskokwim River reported above average chum salmon escapements in 2007, but other than the similarity between the Kogrukluk River weir and the Aniak River sonar projects, inter-annual trends in recent years have been highly variable. In addition to the Kogrukluk River weir and Aniak River sonar projects 2 other projects reported a decrease in annual escapement between 2006 and 2007 (Costello et al. 2008; McEwen *In prep*; Plumb and Harper 2008). In contrast, 3 projects (George, Kwethluk, and Tatlawiksuk river weirs) reported chum salmon escapements in 2007 that exceeded all previous years (Miller and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). Though the spatial variability in relative escapement may be unusually pronounced in 2007, it is not uncommon. Regardless of how they differ between this year and last, chum salmon escapements throughout the drainage in recent years have remained well above the relatively poor levels observed in 1999 and 2000.

Efforts to estimate the abundance of chum salmon in the upper Kuskokwim River drainage and the Holitna River have been met with difficulty due to limitations in methodology and a high degree of sample bias. A study conducted on the mainstem Kuskokwim River estimated total inriver abundance above Kalskag at 675,659 fish in 2002 (Kerkvliet et al. 2003) and 412,443 fish in 2003 (Kerkvliet et al. 2004). A separate study conducted concurrently within the Holitna drainage produced an estimate of 542,172 fish in 2002 and suggested a likely minimum of 400,000 fish in 2003 (Stroka and Brase 2004). A comparison of these estimates suggests that nearly all of the chum salmon above Kalskag escape to the Holitna drainage. This finding is unlikely and emphasizes the need to further refine methods for chum salmon abundance estimation in the Kuskokwim drainage.

The estimates of chum salmon inriver abundance above Kalskag are further suspect when we combine the Holitna estimates with the escapements observed at monitoring projects located on the Aniak, George, Tatlawiksuk, and Takotna Rivers. The sum of these escapements is considerably higher (1,049,969 in 2002, 914,603 in 2003) than the total inriver abundance estimate in both years. In 2002 and 2003 the Kogrukluk River chum salmon represented a relatively small proportion of the Holitna River escapement, and run-timing and composition differed markedly from fish spawning elsewhere in the drainage (Stroka and Brase 2004), which suggests the Kogrukluk River weir alone likely does not adequately index run strength and composition of the entire Holitna or upper Kuskokwim River drainages.

By limiting exploitation, the continuous closure of the commercial fishery in District W-1 until 1 August likely increased annual escapements of Kogrukluk River and other Kuskokwim River chum salmon stocks. The only harvest of chum salmon that did occur in the commercial fishery was taken during coho salmon-directed commercial openings in August. The harvest of 10,763 chum salmon during the coho salmon-directed commercial openings (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication) probably had little effect on tributary escapements. Regardless of whether the proportion of Kogrukluk River fish in the commercial harvest was high or low, the commercial harvest did not significantly impact Kogrukluk River chum salmon.

As with the commercial fishery, the effect of the subsistence fishery on individual Kuskokwim River chum salmon stocks was probably not significant. Unfortunately, the total subsistence harvest for 2007 has not yet been estimated; however, the most recent 10 year average (1997–2006) of 52,439 fish (D. Koster, Research Analyst, ADF&G, Anchorage; personal communication) probably reasonably approximates the 2007 harvest, although this number is preliminary. This subsistence harvest and the relatively small incidental commercial harvest of 10,763 add to a total harvest of less than 70,000 in 2007. Compared to the escapement of 49,505 fish observed at Kogrukluk River weir, the 696,801 estimated in the Aniak River via sonar (McEwen *In prep*), and the escapement of 222,504 across all the other weir projects combined, the total harvest of chum salmon probably did not significantly detract from tributary escapements. These occurrences, combined with the fact that escapements were exceptional in every monitored tributary, indicate there was a harvestable surplus of chum salmon in 2007. However, there were no interested buyers and subsistence user's needs were reduced at this time in the year.

Run Timing at Weir

The timing of the 2007 chum salmon run at the Kogrukluk River weir was much later than average but had an average duration (Figure 19). The central 50% passage in 2007 occurred from 14 to 27 July, compared to the historical average of 8 to 20 July. The 2007 median passage date was 19 July. The earliest median passage date at the project is 9 July (1981, 1988, and 1996), the average is 14 July, and the latest date is 20 July (2005) (Figure 19). All Kuskokwim River escapement monitoring projects observed later-than-average run timing based on median passage dates (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). However, run durations at these projects tended to be average.

Coho Salmon

Abundance

Although the Kogrukluk River weir suffered many inoperable periods, the timing and duration of the high water events had minimal impact on successful enumeration of the 2007 coho salmon run. In addition, a later-than-average project end date helped characterize the end of the run. Consequently, the reported escapement of 27,033 fish is considered an accurate estimate of the total annual escapement past the weir (Table 1). There were a few inoperable days within the coho migration, but only 12% of the total escapement was interpolated for inoperable periods.

Considerable variation in abundance of coho salmon has been observed throughout the 27 year history of coho salmon escapement monitoring at this project (Figure 15). Although annual coho salmon escapement in 2007 was far below the exceptional escapement recorded in 2003, it was still among the highest on record and very near the upper boundary of the current SEG range. In fact, 2007 escapement was considerably above the pre-2004 escapement goal (threshold), which has only been achieved 9 other times. No distinct pattern was obvious for Kogrukluk River coho salmon.

Generally, Kuskokwim River coho salmon escapement was considered average in 2007. Currently, only the Kogrukluk River weir project bears an escapement goal for coho salmon, which limits investigators' ability to assess overall (whole Kuskokwim River) escapement adequacy. The position of the 2007 escapement value near the upper SEG boundary at the Kogrukluk River weir (Figure 20) substantiates investigators' judgment that overall escapement to the Kuskokwim River was probably adequate and sustainable. However, this conclusion is somewhat thwarted by the high degree of variation among projects in 2007. For example, the Kwethluk and Tuluksak river weirs reported record-low annual escapement (Miller and Harper 2008; Plumb and Harper 2008) whereas the George River weir reported an annual escapement near the record-high set in 2003 (Linderman et al. 2004; Thalhauser et al. *In prep*). Regardless of intra-annual inconsistencies in recent years, Kuskokwim River coho salmon did not exhibit the spatially-consistent low abundances in the late 1990s that chum and Chinook salmon did; consequently, they were not subjected to the conservative management practices imposed on Chinook and chum salmon in years following. Furthermore, coho salmon escapements in the Kuskokwim River have not exhibited periodic cycles of increase or decrease like those observed among Chinook salmon.

Commercial harvest pressure on Kuskokwim River coho salmon has always been considerable. Though the commercial harvest of 141,049 coho salmon in 2007 (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication) was probably sufficient to noticeably detract from observed escapements at tributary weirs, the harvest probably represents a relatively low exploitation rate considering the escapements observed in 2007. Total inriver abundance estimates are not available for 2007, but results from the *Kuskokwim River Salmon Mark–Recapture Project* indicated that between 2001 and 2005 inriver abundance of coho salmon ranged from 386,743 (2004) to 928,075 (2003) fish (Pawluk et al. 2006). When compared to the number of coho salmon commercially harvested during these same years, it is obvious that a significant portion of the annual coho salmon spawning population is removed during the commercial fishery. Investigators are not confident in these estimates, however, and a forthcoming study entitled *Kuskokwim River Coho Salmon Investigation* will be addressing that concern through annual inriver abundance estimates (Toshihide Hamazaki, Commercial Fisheries Biometrician, ADF&G, Anchorage; personal communication).

Contrary to the commercial fishery, the effect of the subsistence fishery on individual Kuskokwim River coho salmon stocks was probably not significant. Estimates are not yet available for the 2007, but the preliminary 1997–2006 average harvest estimate of 30,427 fish (Smith et al. *In prep*) is probably a reasonable approximation because annual subsistence harvests have not varied greatly in the past 10 years of available data. Compared to the number of coho salmon captured in the commercial fishery, and recognizing that escapements were near average to high, a subsistence harvest of approximately 30,000 coho salmon probably did not significantly impact escapements of individual stocks, as the exploitation rate of coho salmon for subsistence use is undoubtedly much lower than that for Chinook salmon. The subsistence fishing schedule that was implemented annually from 2001 to 2006 had no effect on coho salmon subsistence harvest practices because, in each year, the schedule was lifted for the season long before coho salmon were passing through the lower river in significant numbers.

Recent coho salmon mark-recapture studies suggest that the Holitna River drainage supports approximately 16% of the total coho salmon escapement to the upper Kuskokwim River drainage (Stroka and Brase 2004; Pawluk et al. 2006). The proportion of the Holitna River escapement that passed the Kogrukluk River weir varied considerably during the 2 year investigation: 23% in 2002 and 47% in 2003 (Stroka and Brase 2004). However, run-timing and composition of coho salmon passing the weir was representative of the entire Holitna system in both years. It appears that the Kogrukluk River weir provides a reasonable index of run-timing and composition for the Holitna system, but its ability to index run strength is questionable.

Conversely, the Kogrukluk River appears to adequately index total inriver abundance above Kalskag by consistently monitoring approximately 5% of the total run (3% to 8% from 2001 to 2005). The proportion of the total inriver abundance above Kalskag escaping to the Kogrukluk River is greater than all other upriver escapement projects. George River generally represents 3% of the total upriver abundance (Thalhauser et al. *In prep*), while Tatlawiksuk and Takotna River weirs represent approximately 2% and 0.6% respectively (Costello et al. 2008; Stewart et al. 2008). The annual proportion of the total run above Aniak monitored by each upriver weir project is fairly consistent across years. These relationships suggest that the Kogrukluk, George, Tatlawiksuk, and Takotna river weirs, singly and in concert, provide a reasonable index of inriver abundance of coho salmon within the upper Kuskokwim drainage. This also reveals that the majority of the Kuskokwim River coho salmon escape to tributaries that are not monitored, and highlights the need for further investigation into the distribution and abundance of this species in the Kuskokwim River drainage.

Run Timing at Weir

The 2007 coho salmon run at the Kogrukluk River weir exhibited slightly earlier-than-average run timing and a slightly shorter-than-average duration for this project (Figure 21). The central 50% passage in 2007 occurred from 23 August to 5 September, compared to the historical average of 25 August to 8 September. In 2007, the median passage date was 29 August. The earliest median passage date at the project is 25 August (1996), the average is 1 September, and the latest date is 10 September (1983, 1990) (Figure 21). Earlier-than-average run timing was observed at George, Tatlawiksuk, Tuluksak, and Kogrukluk river weirs whereas near-average run timing was observed at Kwethluk and Takotna River weirs (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*).

Sockeye Salmon

Abundance

The timing of inoperable periods in 2007 significantly affected sockeye salmon. Most inoperable days coincided with dates historically characterized by high sockeye salmon passage, which reduces investigators' confidence that reported annual escapement reflects actual escapement. Consequently, the reported 2007 escapement of sockeye salmon is not as reliable compared to most recent years. Nevertheless, it is still a valuable indicator of run condition and is adequate to reasonably investigate inter-annual differences and historical trends.

Considerable variation in abundance of sockeye salmon has been observed throughout the 32 year history of escapement monitoring at this project (Figure 15). Although 2007 escapement was not as high as in 2005 and 2006, it was still well above average for this project. No distinct between year pattern is obvious for Kogrukluk River sockeye salmon.

In recent years, sockeye salmon escapements have been unusually high and generally higher than the relatively low escapements that occurred between 1999 and 2003 (Figure 22). There is currently no sockeye salmon escapement goal established for any Kuskokwim River tributary including the Kogrukluk River, which precludes a formal assessment of the adequacy of the escapements.

Little is known about the distribution and abundance of Kuskokwim River sockeye salmon. Sockeye salmon have been observed in several tributaries throughout the drainage (Burkey and Salomone 1999), but only the Kogrukluk and Kwethluk river weirs have a history of enumerating large numbers. A recent investigation aimed at narrowing critical knowledge gaps in the biology and ecology of Kuskokwim River sockeye salmon shows substantial, though previously unknown, spawning aggregates in several middle and upper Kuskokwim tributaries. Of these, the largest concentrations of sockeye occur in the Holitna River system (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage, personal communication). Of particular interest in these systems is the general lack of lentic habitat, which is most commonly associated with sockeye salmon. Preliminary results of this study suggest that the ecological contribution of these atypical "river type" sockeye salmon to the Kuskokwim drainage may be larger than previously believed.

Sockeye salmon in the Kuskokwim River have not been identified as a stock of concern, although escapements may have benefited from the conservation measures implemented to benefit Chinook and chum salmon because they share similar run timing. In fact the incidental harvest of sockeye salmon that occurred during the coho salmon-directed harvest was only 703 individuals (J. C. Linderman, Jr., Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). The actual effect of the combined pressure of subsistence and incidental commercial harvest on Kogrukluk River sockeye salmon is unknown. At time of writing, there are no subsistence harvest estimates for sockeye salmon in the Kuskokwim River for 2007; however, the most recent 10 year average (1997–2006; 2005 and 2006 harvest estimates are preliminary: D. Koster, Research Analyst, ADF&G, Anchorage; personal communication) of 37,077 fish is a reasonable estimate (Smith et al. *In prep*). The subsistence harvest combined with the minimal incidental commercial harvest results in an estimate of approximately 40,000 harvested Kuskokwim River sockeye salmon. These harvest estimates can not be properly compared to weir abundance estimates because most monitored tributaries do not see large escapements of sockeye salmon (Costello et al. 2008; Miller and Harper; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*).

Run Timing at Weir

The timing of the 2007 sockeye salmon run at the Kogrukluk River weir was later than average and one of the latest on record for this project (Figure 23). However, the duration of the run was near average. The central 50% passage in 2007 occurred from 17 to 28 July, compared to the historical average from 10 to 21 July. The 2007 median passage date was 22 July. The earliest median passage date at the project is 9 July (1981), the average is 15 July, and the latest date is 22 July (1999, 2007) (Figure 23). Sockeye salmon run-timing was variable throughout the Kuskokwim River drainage in 2007. Earlier-than-average run-timing was observed at George and Takotna river weirs but was near average at most other projects (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). However, the integrity of these spatial comparisons is limited by the fact that few monitored tributaries support considerable numbers of sockeye salmon.

Pink Salmon

Historically, the contribution of pink salmon to the overall salmon escapement at the Kogrukluk River weir has been negligible, often contributing less than 10 individuals per year. Generally, pink salmon make less extensive spawning migrations into freshwater than other Pacific salmon species (Heard 1991) and, given the spatial orientation of the Kogrukluk River weir (approximately 710 rkm from the mouth of the Kuskokwim River), the small escapements observed at this site are not surprising.

The timing and duration of the inoperable periods that occurred in 2007 probably had an effect on observed pink salmon escapement. Thus, pink salmon escapement data from 2007 are considered unreliable. However, in the previous 2 years a marked increase in escapement had been observed at this project. The observed passage in 2005 of 109 individuals was more than 4 times greater than the previous record of 23 in 1988. This record was surpassed in 2006 when 933 pink salmon were observed. The difference in observed passage of pink salmon between 2005 and 2006 is likely a result of the unique life history strategy of the species; namely, that pink salmon exhibit a fixed 2 year life span resulting in even- and odd-year spawning aggregates that are reproductively isolated (Heard 1991).

Adequate enumeration of pink salmon using weirs is difficult due to the species small size and ability to pass between weir pickets. The recent increase in observed escapement at this project is likely due in part, to a reduction in picket spacing by 1.25 cm at the beginning of the 2005 season. Passage of pink salmon through weir pickets is probably still substantial, and observed escapement likely does not provide an adequate assessment of total annual escapement to this system. However, it does appear that the contribution of pink salmon to this system, although small compared to other Pacific salmon species, is greater than previously believed. To date, the relatively few pink salmon that pass the Kogrukluk River weir are among the farthest known migrating pink salmon in the world (Morrow 1980; Heard 1991), and continued monitoring is needed to better understand the dynamics of this unique stock and its importance to the ecosystem.

No tributary system in the middle to upper Kuskokwim River drainage has a history of enumerating large escapements of pink salmon. Historically (pre-2006), the George River weir averaged 181 individuals per year and the Tatlawiksuk River weir averaged only one fish per year. Only 2 pink salmon have been observed at the Takotna River weir (Costello et al. 2008). The increase in escapement of pink salmon at Kogrukluk River weir appears to be a consistent phenomenon in the Kuskokwim River drainage; the George and Tatlawiksuk River weirs also report marked increases in pink salmon (Costello et al. 2007; Hildebrand et al. 2007). The George River weir enumerated 325 pink salmon in 2007, which was far below the 2006 escapement of 1,232 but relatively high considering the escapements observed in 2004 and 2005 (Thalhauser et al. *In prep*). In addition, the Tatlawiksuk River weir observed 7 pink salmon (Stewart et al. 2008). Consistent with past years, no pink salmon were observed at Takotna River weir (Costello et al. 2008). The picket spacing used at the George and Tatlawiksuk River weirs has not changed in recent years, which supports the conclusion that the observed increase in pink salmon escapements at Kogrukluk River weir is not due solely to changes in methodology, but also a natural increase in. The reason for the increased abundance in upper river tributaries is unknown. Further monitoring is necessary to determine the relevance and possible implications of this observed increase in returns of pink salmon to the Kuskokwim River drainage.

Carcasses

The number of salmon carcasses found on the weir is not a complete census of the number of carcasses that drifted downstream of the weir site. Water levels were generally high throughout the 2007 season, often necessitating partial weir dismantling. High water levels influence reported carcass deposition in 2 ways. First, the number of carcasses and postspawners that wash out of the system is influenced by water conditions; such that high water levels probably increase the rate of carcass washout. Second, carcass deposition was not estimated for inoperable periods; thus, the reported number of carcasses is probably an underestimate. Due to the fact that carcass washout rates are so closely tied to water level it is impossible to standardize the data, making any attempt at trend analysis between years difficult and unreliable. Despite these limitations, some remainder of the spawned-out fish were invariably retained in or near the river upstream of the weir for a protracted period of time, contributing to the productivity of the system through the introduction of marine derived nutrients as described by Cederholm et al. (1999).

AGE, SEX, AND LENGTH COMPOSITION

Chinook Salmon

In years characterized by high escapements of chum salmon, such as 2007, sampling Chinook salmon in 3–5 day pulses has proven impractical. In recent years, Kogrukluk River weir crews have sampled Chinook salmon opportunistically throughout the run and have not adhered to a strict pulse-sample protocol. In 2007, the crew's intent to sample a fraction of escapement every day was periodically interrupted by high water conditions that impaired weir operation and prevented sampling. As a result, actual sample sizes in all 3 strata were considerably less than that necessary to achieve the desired confidence interval widths.

Age Composition

The assortment of age classes seen at the Kogrukluk River weir in 2007 (age 1.2, 1.3, 1.4 and 1.5) are similar to past years, and similar to what has been observed elsewhere in the Kuskokwim Area (Molyneaux et al. *In prep*). Similar to 2006, each dominant age class (age 1.2, 1.3, and 1.4) comprised a virtually identical percentage of the run in 2007 (Figure 24), and was not congruent to the historical norm. At the Kogrukluk River weir age-1.2 fish typically constitute only about 22% of annual escapement whereas age-1.3 fish typically constitute about 36% and age-1.4 fish constitute about 39%. In the presence of high but not exceptional abundance, the above-average percentage of age-1.2 fish equated to an abundance of this age class that was higher than all but 5 the previous years (Figure 24). In contrast, the percentages of age-1.3 and age-1.4 fish were near average despite their unusually low percentages. A suspended commercial fishery, which is restricted to 6 in mesh that targets the smaller and thus younger fish, may have played a role in the increased abundance of age-1.2 individuals. This is however not substantiated and is merely a suggestion of a possible mechanism for the recently observed trend.

The age composition of Chinook salmon at the Kogrukluk River weir was not consistent with other projects in 2007. While here and at all other projects the percentage of age-1.3 fish in 2007 was near average, considerable historical and spatial deviations occurred among the 1.2 and 1.4 age classes. While it is true that the percentage of age-1.2 fish was relatively high at most projects in 2007, the Kogrukluk River stock deviated slightly in that the percentage of this age class was no where near the historical record high as it was in the George, Kwethluk, Takotna, and Tatlawiksuk rivers (Molyneaux et al. *In prep*). For all projects except the Tuluksak River weir, the average percentage of age-1.3 was maintained because a low percentage of age-1.4 fish compensated for the high percentage of age-1.2 fish. In fact, the percentage of age-1.4 fish was record low at George, Takotna, and Tatlawiksuk river weirs and considerably below average at Kwethluk River weir.

The high abundance of age-1.2 fish was not surprising given that Chinook salmon escapement in the 2003 brood year was higher than the 4 preceding years (Figure 16; Shelden at al. 2004). Even a modest rate of survival can yield a high return when parent abundance is high. By this reasoning and assuming survival rates between the 2003 and 2004 cohorts have been similar, it is reasonable to expect a relatively large return of age-1.2 Chinook salmon again in 2008 because escapement in 2004 was also high and actually exceeded that of 2003 (Figure 16; Shelden et al. 2005). The anticipated high abundance of age-1.2 Chinook salmon in 2008 may provide the impetus for relatively high overall (all age classes combined) escapement in 2008. This prediction, especially when considered with respect to the exceptional abundances of Chinook salmon during the 2005 and 2006 brood years, increases the probability that escapements will continue to be relatively high in forthcoming years.

Additional forecasting value comes from the relatively strong sibling relationship that Kuskokwim River Chinook salmon tend to show, wherein the relative strength of each age class produced from a given brood year is often mirrored in subsequent year escapements of sibling age classes (Figure 24; Appendix E1). By this relationship, it is possible to make limited predictions about age-specific run strength in subsequent years based on past sibling returns (Molyneaux et al. *In prep*). For instance, the relatively high abundance of age-1.2 Chinook salmon that occurred in the Kogrukluk River in 2007 suggests a relatively high return of their age-1.3 siblings in 2008; however, the abundance of age-1.4 Chinook salmon in 2008 is not expected to be high following a year in which abundance of age-1.3 was near average (2007). Likewise, the abundance of age-1.5 fish will probably be relatively low again in 2008 following a year with low abundance of age-1.4 fish; however, the 1.5 age class historically comprises only a very small fraction of annual escapement, so deviations in relative abundance of this age class does not greatly influence relative strength of total escapement.

A relatively high abundance of age-1.3 Chinook salmon alone can result in high overall escapement. In this case, however, the concurrent high abundance of age-1.2 and -1.3 fish expected in 2008 will increase the likelihood of high overall escapement to the Kogrukluk River. In general, the widespread occurrence of relatively high abundances of age-1.2 and/or -1.3 Chinook salmon at most projects in 2007 (Molyneaux et al. *In prep*) may provide the impetus for large returns (and escapements) of Chinook salmon drainage-wide in 2008.

The age composition of Kuskokwim River Chinook salmon escaping to the Kogrukluk River drainage varied in concert throughout the 2007 run. As the run progressed, the percentage of young (age-1.2, -1.3) individuals continually decreased while the percentage of older (age-1.4) individuals generally increased (Figure 4). The age-1.3 individuals dominated the early third of the run while age-1.4 individuals dominated the center and last thirds. While age -1.5 individuals only comprised a small percentage of the run they exhibited a general increase as the season progressed. During most years, intra-annual trends among age classes are rarely well-defined. Upon examination of scatter plots generated from historical data (Figure 4), no significant trend is evident. This is consistent with other escapement monitoring projects throughout the Kuskokwim River drainage.

Sex Composition

At 28.4% of the total 2007 escapement (Table 2), the percentage of female Chinook salmon at Kogrukluk River weir was only slightly below 2006 (33%) and the historical average of 34%. The percentage of females in 2007 was well within the historical range, which achieved a high of 60% in 1977 and a low of 16% in 1980 and 2004 (Figure 25). Despite a lower-than-average percentage, the number of females in the Chinook salmon escapement (3,704) was near the historical average (Table 2). Their slightly lower-than-average percentage is attributable to a relatively high abundance of age-1.2 and age-1.3 fish, which are predominantly male, early in the run. Elsewhere in the Kuskokwim River drainage, percentages and abundances of female Chinook salmon were generally low (Molyneaux et al. *In prep*). As mentioned above, it is uncertain what role the commercial fishery, or lack there of plays in the recently observed trends.

At the Kogrukluk River weir, as with most others, the percentage of females tends to increase as the run progresses past the weir (Figure 5). This was observed again in 2007. Regardless of the total percentage of females observed in a given spatial and temporal context, the tendency for the percentage of females to increase as the run progresses is a common trend throughout the Kuskokwim River drainage (Molyneaux et al. *In prep*). Since the majority of females are age-1.4 fish and the majority of males are age-1.2 and/or age-1.3 fish, the timing of each sex through the weir influences the age composition at that time (Figure 4). Consequently, the intra-annual increase in the proportion of females corresponded to the observed increase in age-1.4 individuals during later phases of the run. However, consistent intra-annual trends in sex composition do not translate into consistent intra-annual trends in age composition throughout much of the Kuskokwim River drainage.

Sex composition of the fish sampled for ASL information typically serves as the basis for characterizing the sex composition of the annual escapement. However, concerns are sometimes raised that the physical process required to capture fish for ASL sampling could be selective for or against specific components of the population. In order to assess this potential bias, the crew at the Kogrukluk River weir has been recording the sex of nearly every Chinook salmon observed passing upstream of the weir throughout nearly all of project history. In each year that paired data have been collected, the ASL sampling method has yielded a female percentage similar to the visual method (i.e. usually the difference is less than 5 percentage points; Figure 26).

To reveal whether a sampling bias was present in 2007, data from both methods were compared and analyzed using a *z*-test. For 2007 there was no significant difference between the 2 methods when applied to the total season estimates of sex composition (*z*-test; p = 0.064; Figure 6). However, during the middle strata, the ASL method yielded a significantly higher female percentage than did the visual method (*z*-test; p = 0.027; Figure 6). Though perhaps present, the potential bias between the 2 methods is not great enough to concern investigators.

Length Composition

Mean lengths for each age-sex category in 2007 were within the historical range (Figure 27); however, lengths of male Chinook salmon (both age-1.3 and -1.4 fish) tended to be below average. Lengths of age-1.3 female Chinook salmon tended to be above average whereas age-1.4 females tended to be below average. Mean lengths for females (ages -1.3 and -1.4) increased slightly from 2006 to 2007 whereas mean lengths for males (ages -1.3 and -1.4) decreased slightly. A retrospective analysis of age-1.3 and -1.4 males and females at this project has led some to suggest a general increase in length-at-age between 1984 and 1991, and then a general decrease thru 2007 (Figure 27; Molyneaux et al. *In prep*, Jasper and Molyneaux 2007). However, an increasing trend in mean length from 1984 to 1991 is apparent for only age-1.3 fish; no obvious trend exists for age-1.4 fish at this project during that time period (Figure 23). Furthermore, with each successive year of data collection the decreasing trend in mean length of female Chinook salmon in recent years has faded and since about 1999 mean lengths-at-age have remained relatively consistent.

The observation that female Chinook salmon tended to be longer than males of the same age (Figure 7) was a common pattern throughout the Kuskokwim River drainage in 2007

(Molyneaux et al. *In prep*). Mean length increased with age, and the length range of female age-1.3 and male age-1.4 fish overlapped broadly. Chinook salmon rarely show an obvious intra-annual trend in length by age class over the course of the season, and apparent trends tend to be weak and their significance is unknown (Figure 8; Molyneaux et al. *In prep*). The length of fish in each age-sex category did not change appreciably between the 2 temporal strata in 2007, which is typical for Chinook salmon at Kogrukluk River weir and elsewhere in the Kuskokwim River drainage

Management Implications

Salmon are harvested in both subsistence and commercial fisheries that occur in the mainstem Kuskokwim River far downstream from the Kogrukluk River and other spawning areas (Smith et al. *In prep*; Whitmore et al. 2008). Most harvest is taken with gillnets that are size-selective for discrete components of the returning salmon population. The potential impact of the size-selective harvest is perhaps most consequential to Chinook salmon because they exhibit a wide range of size at maturity (Molyneaux et al. *In prep*).

Subsistence fishers tend to favor using gillnets composed of large-mesh web (e.g., 8 in stretch mesh; Smith et al. *In prep*), so their harvest is selective for larger and older Chinook salmon (Figure 28). This is the same segment of the population in which females are most common (Molyneaux et al. *In prep*). The exploitation rate of the subsistence fishery was estimated to range between 22% and 32% of the total Kuskokwim River Chinook salmon runs in the years 2002, 2003, 2004, and 2005 (Molyneaux and Brannian 2006).

In contrast, commercial fishers are limited to using 6 in or smaller mesh sizes (Whitmore et al. 2008), so their harvest is selective for smaller Chinook salmon in a size range dominated by males (Figure 28). The timing of the commercial fishery tends to be more towards the second half of the Chinook salmon run; however, in recent years low market interest has resulted in very limited commercial harvest (Whitmore et al. 2008). Exploitation rates from the commercial fishery are estimated to have been no more than 1.6 percent in the 2002 to 2005 run reconstructions (Molyneaux and Brannian 2006).

The Chinook salmon seen at the Kogrukluk River weir and within spawning areas elsewhere in the Kuskokwim River consist of the fraction of fish that escape harvest. The selectivity of that harvest influences the resulting age, sex, and length composition in the escapement (Figure 28). In 2007, the subsistence fishery had a much greater impact on tributary escapement composition than the commercial fishery since nearly the entire harvest of Chinook salmon occurred in the subsistence fishery. Since subsistence fishers tend to favor large-mesh gillnets (e.g., 8 in stretch mesh; Smith et al. *In prep*), their fishing efforts are selective for larger fish. This size selectivity coupled with the relatively high exploitation rate increased the incidence of smaller Chinook salmon, which are usually male, and decreased the incidence of larger fish, which are usually female (Figure 28).

Chum Salmon

Nearly every stipulation of Objective 2 was achieved in regards to chum salmon in 2007. The only shortfall was in respect to the temporal distribution of the sampling effort—the central one-third of the run was not well represented in the sample. However, this shortfall has little practical implications. Since the position of the sampling effort within the run progression cannot be controlled during the season, it is impractical to retain it as a requirement of the objective.

Age Composition

The assortment of age classes seen at the Kogrukluk River weir in 2007 (age 0.2, 0.3, 0.4, and 0.5) are similar to past years and to what has been observed elsewhere in the Kuskokwim Area (Molyneaux et al. *In prep*). The percentages of age-0.2, age-0.3, and age-0.5 fish were slightly above average whereas the percentage of age-0.4 fish was slightly below average. The abundance of fish in each age class was above average, leading to an above-average overall escapement. Historically (and in 2007), age-0.3 fish compose the majority of the escapement at the Kogrukluk River weir (Figure 29). In fact, age-0.3 was the dominant age class at all projects throughout the Kuskokwim River drainage in 2007 (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). Historical trends in age composition tend to vary spatially and temporally throughout the Kuskokwim River drainage; however, age-0.3 and -0.4 fish have consistently comprised the majority of the run at all escapement projects (Molyneaux et al. *In prep*). In 2007 age-0.3 and -0.4 fish combined composed over 93% of the total annual escapement at every Kuskokwim River escapement project.

The significance of the high abundance of age-0.3 chum salmon in 2007 is that it suggests a relatively strong return of their age-0.4 siblings in 2008. Likewise, the relatively high abundance of age-0.2 chum salmon in the Kogrukluk River weir and most other projects in 2007 indicates the potential for a high return of age-0.3 fish in 2008. Unfortunately, sibling relationships for chum salmon are not as reliable as with Chinook salmon, even with the relatively low and stable harvest that has occurred since 1999 (Figure 29; Appendix E2; Smith et al. *In prep*). High abundances of age-0.3 and age-0.4 chum salmon in 2008 at the Kogrukluk River weir and other projects will probably equate to high overall escapement.

Age composition of the chum salmon escapement varied only slightly as the 2007 run progressed past the Kogrukluk River weir and no age class adhered to a consistent increasing or decreasing trend (Figure 9). The later 3 strata were dominated by younger, age-0.3, individuals whereas the first stratum was dominated by older, age-0.4 individuals. The trend that commonly occurs in the Kogrukluk River in which the percentage of age-0.3 fish tends to increase while the percentage of age-0.4 fish tends to decrease during the run was not well substantiated in 2007. In 2007 this inverse relationship between the percentage of age-0.3 and -0.4 chum salmon was not widely observed (Molyneaux et al. *In prep*).

Brood tables provide the tools to investigate potential cohort survival and assess the number of returns per spawner (Appendix E2). For chum salmon, total return is calculated as the sum of all individuals between 3 and 6 years of age returning from a specific brood year. The most recent return number available in any given year is from the brood year 6 years before (2001 in this case). As with other projects in the Kuskokwim River drainage, return data for the Kogrukluk River do not include the fraction of Kogrukluk River chum salmon harvested in downstream fisheries. For chum salmon, the number of fish harvested in the subsistence fishery may be large enough to noticeably detract from escapement, so the return values presented in Appendix E2 underestimate actual returns. However, since subsistence harvests of chum salmon tend to vary with abundance, the values presented in this report are probably reasonable indexes of total returns to the Kogrukluk River.

Consistent ASL sampling effort has allowed calculation of return for all brood years between 1996 and 2001 and return per spawner can be calculated for all but 1998 (Appendix E2).

Historically, return-per-spawner values have ranged from 0.43 for the 1996 brood year to 3.78 for the 1997 brood year. The 8.26 returns per spawner determined for the 2001 brood year, the most recent for which it can be calculated, greatly exceeds that of any previous year. There are only a few years available from which to draw comparisons, which limits the validity of conclusions and makes it difficult to determine with confidence whether total returns in subsequent years were higher or lower than expected. Despite this shortfall, a return-per-spawner value of 8.26 indicates that the total number of surviving offspring from the 2001 brood year amounted to over 8 times the escapement of their parents.

Sex Composition

At 37.6% of the total 2007 escapement (Table 4), the percentage of female chum salmon at the Kogrukluk River weir was similar to 2006 (38.2%; Liller et al. 2008) but slightly above the historical average of about 34%. The percentage of females in 2007 was well within the historical range, which reached a high of 49% in 1982 and a low of 4% in 1997 (Molyneaux et al. *In prep*). From 1990 through 2004 the percentage of females at this project had generally been low and averaged only 18% annually. In contrast, the percentage of female chum salmon has been near 50% in most other Kuskokwim Area data sets (Molyneaux et al. *In prep*). Like the Kogrukluk River weir, all other Kuskokwim Area escapement monitoring projects in 2007 reported a proportion of females consistent with past years (Costello et al. 2008; Miller and Harper 2008; Plumb and Harper 2008; Stewart et al. 2008; Thalhauser et al. *In prep*).

The last 3 consecutive years have witnessed a considerable increase in the percentage of females returning to this system (Figure 25), which is a change that coincided with the use of a tighter picket spacing in 2005. Investigators considered the possibility that the extreme sex ratios during the 1990s and earlier this decade were erroneous and a consequence of the wider picket spacing employed during these years that may have encouraged the passage of females but prevented the passage of males. However, examination of length frequency histograms in past years does not indicate that smaller fish have been underrepresented to such a degree as to account for the anomalous sex ratios that were observed (Jasper and Molyneaux 2007; Liller et al. 2008).

The historically low female percentages observed at the Kogrukluk River weir may have been the consequence of weir location and differences in spawning behavior between males and females, rather than inappropriate picket spacing. The Kogrukluk River weir differs from others in the Kuskokwim River area in that it is located upstream from a large stretch of spawning habitat. Because of differences in spawning behavior between male and female salmon, the location of the weir relative to spawning habitat may influence the percentage of females passing through the weir. Schroder 1982 reports observations of male salmon that continued upstream a considerable distance after initial spawning, while females tended to remain near their redds (Schroder 1982); therefore, males may be more likely to be found in higher concentrations higher in the drainage than females, and more may be counted through the weir. If this is true, then the percentage of females counted through the Kogrukluk River weir in a given year may be more closely tied to abundance. In years of high abundance, such as 2005, 2006, and 2007, downstream spawning habitat may have been saturated with redds, which probably induced more females to migrate further upstream and through the weir. For example, investigators suspect that in 2005 the percentage of females may have been high (45.1%) as a consequence of the exceptionally high abundance of chum salmon in the Holitna River system that year (197,723 fish were counted through the weir; Jasper and Molyneaux 2007). However a strong correlation between chum salmon abundance and the percentage of females is not apparent.

Stratified sampling at the Kogrukluk River weir revealed only slight changes in sex composition as the run progressed and no consistent trends were apparent. Historically, Kogrukluk River chum salmon sex composition tends to change little during the run and intra-annual variation does not generally follow a positive or negative trend (Figure 5). At some monitoring projects it is common for the percentage of females to continually increase during the run (Molyneaux et al. *In prep*). Since most female chum salmon are 4 year old fish (age-0.3) intra-annual changes in sex composition tend to equate to intra-annual changes in age composition.

Length Composition

In 2007 at the Kogrukluk River weir, mean lengths of chum salmon for all age-sex categories were below than historical averages (Figure 30) and some of the lowest on record for this project. A retrospective analysis of age-0.3 and -0.4 male and female chum salmon at this project shows a general increase in length-at-age between 1984 and 1996, and then a general decrease through 2007 (Molyneaux et al. *In prep*, Jasper and Molyneaux 2007). This decreasing trend is most obvious among age-0.3 and -0.4 males. The tighter picket spacing that has been used in recent years (2005 to 2007) may be partially responsible for the lower mean lengths at age in recent years—prior to 2005 fish were occasionally observed passing between the pickets but there have been no reports of this occurring between 2005 and 2007. However, the decreasing length frequency trend has been occurring since 1996, well before picket spacing was adjusted, indicating that the decreased picket spacing is not the sole reason. Furthermore, the Tatlawiksuk, Takotna, and George River weirs all displayed similar decreasing trends for all age-sex categories (Costello et al. 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). More likely, the decreasing size trend among chum salmon may have allowed increasing numbers of fish to pass between pickets over the years, until the picket spacing was adjusted in 2005.

Although lengths were smaller than average in 2007 at Kogrukluk River weir, mean length increased with age, and males were larger than females of the same age (Figure 7). Both occurrences are fairly consistent trends at this project (Figure 30) and throughout the Kuskokwim River drainage (Molyneaux et al. *In prep*). Chum salmon rarely exhibit a strong intra-annual trend in length-at-age over the course of the season, but a slight decrease in length-at-age as the run progresses has been consistently observed at this and other Kuskokwim Area projects (Figure 10; Molyneaux et al. *In prep*). In summary, as the run progressed, the overall age and length composition shifted from an older and larger run to one consisting of smaller and younger individuals.

Coho Salmon

Sampling goals for Kogrukluk River coho salmon were nearly achieved in 2007. With pulse samples positioned around 17%, 59%, and 94% of the coho salmon run past the weir, the distribution of the sampling effort was nearly ideal for estimating the ASL composition of the total run as well as in 3 strata. Furthermore, the total aged sample of 394 coho salmon was more than adequate to estimate the ASL composition of the total run with confidence interval widths of less than 0.20. Unfortunately, the number of fish sampled in each pulse for which age could be determined (i.e. postaging sample) was not sufficient to achieve the desired confidence interval width for any individual stratum (Table 6). In short, more fish were removed from the sample(s) due to aging difficulties than was anticipated and accounted for by the sampling goal. Though actual per-pulse samples sizes result in confidence intervals slightly wider than desired, intra-annual changes in ASL composition can be reasonably investigated, especially considering the fair distribution of sampling effort.

Age Composition

Kuskokwim River coho salmon are predominantly age-2.1 (4 year old) fish. At escapement projects throughout the drainage, age-2.1 coho salmon typically comprise about 90% of annual escapement (Molyneaux et al. *In prep*). Other age classes may fluctuate historically in terms of relative contribution, but their percentages are always low compared to age-2.1 fish (Molyneaux et al. *In prep*). At the Kogrukluk River weir in 2007, age-2.1 coho salmon comprised 90.7% of the total run whereas age-3.1 and age-1.1 together comprised less than 10% (Table 6). Though numbers were small compared to age-2.1 fish, the abundance of age-1.1 fish was above average in 2007 whereas the abundance of age-3.1 fish was considerably below average.

The idea that the abundance of one age-class one year can predict the abundance of their siblings the next year (one year older) has limited utility when applied to coho salmon. First, nearly all Kuskokwim River coho return as age-2.1 individuals, so deviations in the abundance of other age-classes will have little effect on total annual escapement. Second, historical data do not show that such predictions are reliable (Figure 24). Applied to 2007 escapement data, the high abundance of age-2.1 coho salmon does not guarantee a high abundance of age-3.1 fish in 2008, nor does the relatively low abundance of age-1.1 fish forecast an unusually low abundance of age-2.1 fish. Furthermore, the total return of the Kogrukluk River stock cannot be determined because it is not known how many Kogrukluk River coho salmon are harvested in downstream fisheries.

Despite these limitations, one prediction did hold true: the record-high abundance of age-1.1 fish observed in the 2006 escapement at this project (1,812 fish) was followed by a higher-than-average abundance of age-2.1 fish in 2007 (24,527 fish; Table 6). The strong returns of age-1.1 fish in 2006 and age-2.1 fish in 2007 may be the result of the exceptional abundance of spawners observed during the 2003 brood years. However it is important to note that sibling relationships historically are not reliable for Kuskokwim River coho salmon and managers do not generally focus on sibling relationships in preseason forecasting.

Age composition of the coho salmon escapement varied little as the 2007 run progressed past the Kogrukluk River weir with age-2.1 individuals being dominate for the entire run (Figure 9). Coho salmon do not usually exhibit consistent trends in the Kogrukluk River or in other tributaries of the Kuskokwim River (Molyneaux et al. *In prep*). This temporal consistency mitigates difficulties that arise when sampling distribution is poor.

Brood tables provide the tools necessary to investigate potential cohort survival and the number of returns per spawner (Appendix E3). For coho salmon, total return is calculated as the sum of all individuals between 3 and 5 years of age returning from a specific brood year. The most recent return number available for a given year is from the brood year 5 years before (2002 in this case). As with other projects in the Kuskokwim River drainage, return data for the Kogrukluk River do not include the number of Kogrukluk River coho salmon harvested annually in downstream fisheries. For coho salmon, the number of fish harvested in the commercial fisheries may be large enough to noticeably detract from escapement, so the return values presented in Appendix E3 underestimate actual returns. However, the values presented in this report are probably reasonable indexes of total returns to the Kogrukluk River. Consistent ASL sampling effort has allowed the calculation of return and return per spawner for 1990, 1991, and every brood year between 1995 and 2002 (Appendix E3).

Return-per-spawner values have ranged from 0.44 for the 1995 brood year to 5.33 for the 1990 brood year. The broods from 1990 and 1999 exhibited exceptional survival and were responsible for the extreme coho salmon escapements observed at the Kogrukluk River weir in 1994 and 2003, respectively (Burkey 1995; Shelden et al. 2004) . The high return-per-spawner values calculated for the 1990 and 1999 brood years (5.33 and 5.08, respectively) are obvious outliers; except for these 2 years, return-per-spawner values have not exceeded 1.84 in the history of the project. In fact, the return-per-spawner value for the 2002 brood year (1.22) was higher than that of most other years and, though modest in comparison to 1990 and 1999, indicates that the total number of surviving offspring from the 2002 brood year were 22% more abundant than their parents.

Sex Composition

At 44.6% of the total 2007 escapement (Table 6), the percentage of female coho salmon at the Kogrukluk River weir decreased slightly from 2006. However, it was still considerably above the historical average of 37.9%. The percentage of females among Kuskokwim River coho salmon stocks was spatially variable in 2007 and ranged from 32% at the Tuluksak River weir (Plumb and Harper 2008) to 52% at the Takotna River weir (Costello et al. 2008). Similar to the Kogrukluk River, deviations from historical averages were minimal (Molyneaux et al. *In prep*). Historically, the percentage of female coho salmon has been near 50% in most Kuskokwim Area data sets.

The annual percentage of female coho salmon at the Kogrukluk River weir has ranged from a low of 14% in 1990 to a high of 55% in 2006 (Molyneaux et al. *In prep*). The slightly above-average percentage of female coho salmon that occurred in 2007 equated to a relatively high abundance of females rather than a lowered abundance of males (12,060; Figure 25). Though considerable annual variation has been observed at this project, the incidence of females has generally been increasing slightly since the start of coho salmon monitoring in 1981. This trend has not been observed elsewhere in the Kuskokwim River drainage. The reason for the increase in the incidence of females is unknown, but does not generally appear to be correlated to abundance.

Stratified sampling at the Kogrukluk River weir in 2007 revealed considerable changes in sex composition during the coho salmon run. In 2007, the percentage of female coho salmon increased continually from the first stratum to the last (Figure 5), a trend that is historically consistent at the Kogrukluk River weir and consistent with most other projects in 2007 (Molyneaux et al. *In prep*). However, this trend has not occurred often enough throughout the Kuskokwim River drainage to be considered the norm. In most years, the percentage of female coho salmon is higher in the last stratum than in the first, but percentages tend to vary widely between strata.

Length Composition

Annual mean lengths of male and female age-2.1 coho salmon at the Kogrukluk River weir have generally been declining since the late 1990s (Figure 31). Mean lengths in 2007 were significantly below those in most years between 1990 and 2003; however, they were similar to those in 2004 and 2005. Coho salmon escapement in 2006 was marked by abnormally short fish and mean lengths for both male and female age-2.1 fish were far below any other year including 2007 (Liller et al. 2008). This pattern of decreasing length for both male and female age-2.1 fish has been observed throughout the Kuskokwim River drainage, but usually to a lesser degree (Costello et al. 2008; Molyneaux et al. *In prep*; Stewart et al. 2008; Thalhauser et al. *In prep*). Similar to past years for this project, no consistent intra-annual pattern was obvious in the average length composition (Figure 12). Across all Kuskokwim River datasets mean length does tend to increase as the season progresses (Molyneaux et al. *In prep*), but this pattern is highly variable and was not observed at the Kogrukluk River weir in 2007. It is important to note that low sample sizes and the absence of long term escapement monitoring at Kuskokwim River projects may preclude accurate inter-annual trend analysis.

In 2007 females were significantly longer than males of the same age (Figure 7; Molyneaux et al. *In prep*). Though this phenomenon is not common among Kuskokwim River coho salmon, it was a widespread occurrence in 2007 (Costello et al. 2008; Stewart et al. 2008; Thalhauser et al. *In prep*). Where mean lengths in 2007 fall in relation to past years varies among projects, but most reported mean lengths near their respective historical averages and an increase from 2006 (Molyneaux et al. *In prep*).

Sockeye Salmon

The collection of ASL data from sockeye salmon ceased being a primary objective of the weir project in 1995. Investigators realized the high incidence and magnitude of scale absorption inhibited reliable aging (Burkey 1995; Cappiello and Burkey 1997). Still, records of annual sex composition have been maintained because crews continue to estimate sex composition visually as the fish migrate past the weir.

Comprehensive ASL sampling of sockeye salmon was reinitiated at the Kogrukluk River weir in 2006 in support of *Kuskokwim River Sockeye Salmon Investigations*. ASL data collected from sockeye salmon in 2006 and 2007 serve a different purpose and the manner in which they were collected reflected the requirements of the sockeye salmon investigations project rather than the ASL sampling protocol followed for chum and coho salmon. However, these data do lend themselves to modest historical comparisons and trend analysis.

Sex Composition

Ensuing discussion of sockeye salmon sex composition will be based on the female percentage derived from the non-ASL (visual) method rather than that provided through ASL sampling for 2 reasons. First, the earliest stages of the sockeye salmon run was not well represented in the 2007 sample because sampling did not commence until 54% of the run had migrated past the weir site (Tables 1 and 8). Second, for most of project history comprehensive ASL data were not collected for sockeye salmon and data are lacking for historical comparisons. The concern implied by the latter point is that the 2 methods may yield different percentages, which make them incomparable. In 10 out of 12 years of paired data, the female percentage derived from ASL sampling was less than the percentage derived from the non-ASL method (Figure 26). When applied to the total 2007 escapement, the percentage of females observed through regular counts yielded a total female passage of 7,882. Incidentally, the ASL method yielded only 6,531 fish, though sampling was not applied consistently across the run.

The percentage of female sockeye salmon as determined through regular counts (i.e. not ASL sampling) in 2007 (47.7%) was similar to 2006 (51.9%) but slightly above the historical

(1976-2006) average of 40.1%. However, this average is largely influenced by exceptionally low (i.e. < 20%) female percentages in 1976, 1977, and 1998, and the average computed excluding these years is much more similar to the percentage observed in 2007. Annual percentages of female sockeye salmon (based on non-ASL methods) have ranged from a minimum of 14% in 1976 to 69% in 1983; both these extremes were corroborated by ASL sampling conducted simultaneously during these years. The annual percentage of female sockeye salmon tended to decline throughout most of the 1990s, but since about 2000 annual percentages have been highly variable with no apparent trend. The cause of the decline in females during the 1990s is unknown, but does not appear to be correlated to abundance. Of all escapement-monitoring projects operated in the Kuskokwim River drainage, only the Kogrukluk and Kwethluk River weirs have a history of enumerating large escapements of sockeye salmon (Miller and Harper 2008). Spatial comparisons involving other projects are impaired by a lack of data. However, all sources of sockeye salmon sex data do not suggest a clear inseason temporal pattern for sex composition (Molyneaux et al. *In prep*).

WEATHER AND STREAM OBSERVATIONS

Water levels were generally high while water temperatures were generally low throughout most the Chinook, chum, and sockeye salmon runs (Figures 32 and 33). Overall, water level was variable throughout the season with seasonal highs occurring in early July and seasonal lows occurring near the end of August. The 2007 average water temperature of 10.3°C derived from thermometer measurements (Appendix C1) was slightly lower than the historical average of 11.0°C. The average water temperature determined by the data logger (10.0°C) was also below the historical average; however, direct comparisons should be avoided because in 2007 the data logger did not begin recording until 18 July, so the average calculated with this method did not include observations early in the season and is not representative of the entire period of weir operations. It is unclear whether water temperature affected salmon passage because changes in water temperature at Kogrukluk River weir usually occur concurrently with fluctuations in water level. Generally, no obvious relationship between fish passage and water temperature has been reported for this project.

Similar to past years at this project, no obvious relationship was observed between Chinook, chum, sockeye or coho salmon passage through the weir and local weather conditions. However, peak salmon escapement dates of the 2007 year did seem to coincide with an increase in water level (Table 1; Figure 33), but this effect could be produced from a number of different causes most likely resulting from complementary timing of the salmon runs and increases in water level. Past years at this project have also seen a similar relationship (Jasper and Molyneaux 2007). In addition, this behavior is more pronounced in coho and has been observed in other stocks of coho salmon throughout their range (Sandercock 1991). However, in 2007 peak coho escapement fell after high water events and coho salmon were not observed milling in large numbers below the weir prior to the high water event, possibly indicating a reluctance to move upstream. Furthermore, the run-timing of coho salmon past the weir was earlier than average with median passage dates coinciding with the lowest water levels of the season (Figures 21 and 33). These observations suggest that the increased daily salmon escapement was probably not directly caused by increased water level and that any concurrent timing was coincidental.

RELATED FISHERIES PROJECTS

Kuskokwim River Chinook Salmon Run Reconstruction

Tag deployment efforts were successful in 2007. The Chinook salmon abundance estimates generated as one component of the project mark the sixth year that an abundance estimate was determined for the Kuskokwim River drainage upstream of the Aniak River confluence, and the second year that an abundance estimate could be calculated that includes the Aniak River. The deployment of anchor tags in addition to radio tags provided a tag sample large enough to investigate travel speed and run timing, thereby providing an additional year for historical comparisons of these measures.

At the time of publication, development of the model required for a comprehensive run reconstruction was ongoing. Until the model is completed, historical abundance estimates can not be computed. Results and discussion of success will be reported in a separate publication that will be written upon completion of historical run abundance estimates (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication).

Abundance Estimate

Project investigators in 2007 worked closely with investigators from the former *Inriver Abundance of Chinook Salmon in the Kuskokwim River* project to ensure that methods remained consistent (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication; Stuby 2007). Generally, the same limitations and assumptions of the former project persist in the current. For example, Chinook salmon smaller than 450 mm MEF were not radio-tagged, so abundance estimates generated then and now do not include the fraction of the Kuskokwim River Chinook salmon run below this threshold. However, the annual abundance estimates generated without this component likely do not greatly underestimate the total abundance inclusive of fish less than 450 mm MEF because such small Chinook salmon are uncommon in the Kuskokwim River (Molyneaux et al. *In prep*). At the Kogrukluk River weir, for example, these small Chinook salmon only comprise about 0.6% of the ASL sample. Other weirs have reported lower percentages.

Run Timing and Travel Speed

The run timing information derived from pooling the radio-tag and anchor-tag samples from *Kuskokwim River Chinook Salmon Run Reconstruction* indicates slight variation in stock-specific run timing in 2007. In 2007, as in most past years, there was a noticeable inverse relationship between natal stream distance and time of passage past the Kalskag tagging sites. Based on median passage dates, stocks with the furthest to travel tended to arrive earlier than stocks bound for tributaries nearer the tagging sites. The earliest arriving stocks were Takotna and Tatlawiksuk; both had a median passage date (at the Kalskag tagging sites) of 24 June (Figure 34). Consistent with this pattern, George River and Salmon River fish tended to arrive later (29 and 30 June, respectively), but, contrary to this pattern fish bound for the Kogrukluk River arrived after those bound for the Tatlawiksuk River (28 June) despite the Kogrukluk River's greater distance from the tagging sites. Though sample sizes are small, the median passage dates for tagged Takotna River Chinook salmon past the tagging sites have been the earliest of any stock in 2 of the 5 years with comparable data. In the remaining years only the Tatlawiksuk stock arrived earlier (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication).

Travel speed and run timing indicators provided by the Chinook salmon radiotelemetry and anchor tagging projects are valuable tools for fishery management. The timing of commercial fishery openings is considered with respect to the stock-specific run timing evident through the tagging and tracking of Chinook salmon. Relatively low subsistence and Bethel Test Fishery catches during a period when Chinook salmon should have been abundant based on tagging data contributed to the management decision to keep the commercial fishery closed until 1 August after which time management strategy shifted to coho salmon. In retrospect, what was interpreted as low abundance was actually the effect of relatively late run timing. Regardless, very few Chinook salmon were harvested in the August coho-directed fishing openings and run timing and travel speed data obtained from tagging studies further ensure that virtually no Kogrukluk River Chinook salmon were harvested in the commercial fishery. Though irrelevant in 2007, the commercial fishing periods that usually occur in late June probably miss stocks bound for the Kogrukluk River weir due to the early run timing of upper river stocks relative to stocks from tributaries further downriver. Though in some years Kogrukluk River Chinook salmon may comprise a minute fraction of the total commercial harvest, the impact of the Kuskokwim River commercial fishery on individual salmon stocks is negligible when considered with respect to the total abundance estimates developed as part of *Inriver Abundance of Chinook Salmon in the Kuskokwim River* and *Kuskokwim River Chinook Salmon Run Reconstruction.* Due to fewer restrictions and greater annual harvest, the subsistence fishery likely had a much greater impact on Kogrukluk River Chinook salmon.

Kuskokwim River Sockeye Salmon Investigations

For the third consecutive year, sockeye salmon radio tag deployment efforts were successful. The deployment of anchor tags in addition to radio tags provided a sample large enough to investigate travel speed and run timing, thereby providing an additional year for historical comparisons of these measures. A total of 69 tagged sockeye salmon were recorded as having passed the Kogrukluk River weir in 2007. Of these, 48 were radio-tagged and 21 were anchor-tagged. The 48 radio-tagged sockeye salmon detected represented about 12% of the total radio-tagged sample (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). The 21 anchor-tagged sockeye salmon observed represented about 3% of the total anchor-tagged sample. The high proportion of tagged sockeye salmon seen at the Kogrukluk River was not unexpected because radiotelemetry data collected between 2005 and 2007 indicate that the bulk of radio-tagged sockeye salmon spawn in the Holitna River and its tributaries. This implies that the Holitna River system is probably the largest sockeye salmon producing tributary in the Kuskokwim River and the Kogrukluk River may be more important for sockeye salmon production than previously thought.

Run Timing and Travel Speed

Data collected in support of *Kuskokwim River Sockeye Salmon Investigations* supplement data collected during the former *Kuskokwim River Salmon Mark-Recapture Project* in illustrating stock-specific run timing and travel speed. The run timing information derived from pooling the radio-tag and anchor-tag samples from this year's *Kuskokwim River Sockeye Salmon Investigations* study suggests slight variation in stock-specific run timing in 2007. Figure 35 illustrates that tagged sockeye salmon bound for Kogrukluk River arrived at the tagging sites slightly ahead of the total sockeye migration.

Fewer sockeye salmon were tagged in 2007 than during most years of the mark-recapture study (2002–2006). Mark-recapture data from 2002 to 2005 suggest an inverse relationship between natal stream distance and stock-specific run-timing; that is, sockeye salmon stocks bound for tributaries farthest upriver tend to pass through the tagging site earlier than stocks bound for tributaries nearer the tagging site (Pawluk et al. 2006). In each year with comparable data, fish bound for Telaquana Lake are generally the first captured and tagged, followed in order of timing by fish bound for the Kogrukluk, Tatlawiksuk, and George rivers. In 2007, the Kogrukluk River stock exhibited a run-timing (past the tagging site) similar to 2006 (K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication) but slightly later than the average date seen between 2002 and 2005; however, the overall stock-specific run-timing results did not follow the previously observed pattern. In fact, with the exception of the Kogrukluk River stock, the 2007 pattern appears opposite what has previously been observed (Pawluk et al. 2006; K. L. Schaberg, Fishery Biologist, ADF&G, Anchorage; personal communication). The George River stock had the earliest run timing of the 2007 season followed by Salmon, Kogrukluk and Tatlawiksuk River fish, respectively (Figure 35). With the exception of the Kogrukluk River, earlier-than-average run timing was observed among all Kuskokwim River stocks. Unfortunately, small tag samples confound reliable trend analysis and only the Kogrukluk River weir has consistently received an adequate tag sample for confident assessment of run timing.

Travel speed and run-timing indicators derived from pooling the tag samples from *Kuskokwim River Salmon Mark–Recapture Project* and *Sockeye Salmon Investigations* are valuable tools for fishery management. The timing of commercial fishery openings is considered with respect to the stock-specific run-timing and speed evident through tagging and tracking sockeye salmon. Though data are lacking for most projects in 2007, the information obtained from tagged sockeye salmon at the Kogrukluk River weir reveals an average travel speed of about 20 km/day, which is similar to past years. Assuming that travel speed remained constant along the migration path from the coast to the spawning grounds, the majority of these fish (the central 50% passage) would have been passing through District W-1 (rkm 0-203) from approximately 18 to 25 June. Being directed at coho salmon, the only commercial harvest that occurred in 2007 did not open until 1 August, well after the bulk of the sockeye salmon run had already moved through the lower river. Thus, most sockeye salmon were spared from commercial harvest pressure.

CONCLUSIONS

ESCAPEMENT MONITORING

- The weir was installed on 26 June and was operational through 23 September.
- The weir was not operational for 24 days due to high water and heavy debris load.
- Total annual escapement of 13,029 Chinook salmon in 2007 was not a record; however it was a strong run and was near the upper boundary of the SEG range.
- Similar to the Kogrukluk River weir, most escapement monitoring projects witnessed a relatively high Chinook salmon escapement.
- The commercial fishery probably had a negligible impact on Kogrukluk River Chinook salmon escapement, but the subsistence fishery likely had a considerable impact.

- At-the-weir run timing of Chinook salmon at the Kogrukluk River weir was later than average, which was similar to most other projects.
- Total annual escapement of 49,505 chum salmon in 2007 was the sixth highest on record and slightly exceeded the SEG range.
- Similar to the Kogrukluk River weir, most escapement monitoring projects witnessed a relatively high chum salmon escapement.
- Neither the commercial fishery nor the subsistence fishery had a considerable impact on Kogrukluk River chum salmon escapement.
- At-the-weir run timing of chum salmon at the Kogrukluk River weir was later than average, which was similar to most other projects.
- Total annual escapement of 27,033 coho salmon in 2007 was within and near the upper boundary of the SEG range.
- The position of 2007 escapement relative to past years was highly variable among projects; still, most projects reported average or above average escapements.
- At-the-weir run timing of coho salmon at the Kogrukluk River weir was earlier than average, which was similar to most other projects.
- Total annual escapement of 16,525 sockeye salmon in 2007 was less than 2005 and 2006 but still relatively high.
- Like the Kogrukluk River weir, most escapement-monitoring projects reported smaller escapements in 2007 than in the recent 2–3 years; however, escapements were generally above average drainage-wide.
- At-the-weir run timing of sockeye salmon at the Kogrukluk River weir was later than average.

AGE, SEX, AND LENGTH COMPOSITION

- Postseason analysis revealed that ASL sample collections for Chinook, chum, and coho salmon were sufficient for estimating the age, sex, and length composition of total annual escapement.
- The Chinook salmon run was nearly uniformly represented by age-1.2, -1.3, and -1.4 fish. The percentage of young (age-1.2 and -1.3) fish decreased throughout the run while the percentage of older (age-1.4) fish increased.
- Assuming consistency in ocean survival, the high abundance of age-4 Chinook salmon in 2007 forecasts a high abundance of age-5 Chinook salmon in 2008. Similarly, the average abundances of age-5 and age-6 Chinook salmon in 2007 forecasts average abundances of age-6 and age-7 fish in 2008, respectively.
- The relatively high return of age-4 fish from a brood year of relatively high abundance (2003) and the average returns of age-5 and age-6 fish from brood years of average abundance (2001 and 2002) suggests typical marine survival in recent years.

- Female Chinook salmon made up approximately 28% of the total annual run. The percentage of females increased as the run progressed.
- The Chinook salmon run showed length partitioning by sex and age class. Average length increased with age and females were longer than males at age.
- The chum salmon run was primarily represented by age-0.3 and -0.4 fish. The percentage of age-0.4 fish decreased as the run progressed while the percentage of age-0.3 fish increased.
- The relatively high return of age-0.2 and age-0.3 chum salmon from brood years of below average abundance (2003 and 2004) suggests high marine survival whereas the above average return of age-0.4 and age-0.5 chum salmon from brood years of average abundance (2001 and 2002) suggests typical marine survival.
- Assuming consistency in ocean survival, the high abundance of age-0.2, age-0.3, and age-0.4 chum salmon in 2007 may indicate a relatively high return of age-0.3, age-0.4, and age-0.5 fish to the Kogrukluk River in 2008.
- Female chum salmon made up approximately 38% of the total annual run. The percentage of females increased slightly as the run progressed. The percentage of female chum salmon observed in the last 3 years is considerably higher than that observed since the late 1980s.
- The chum salmon run showed length partitioning by sex and age class. Average length increased with age and males were larger than females at age.
- Mean lengths-at-age of male and female chum salmon were some of the smallest on record for this project.
- The coho salmon run was dominated by age-2.1 fish. The percentage of each age class (age-1.1, -2.1, and -3.1) remained nearly constant during the run.
- The average return of age-2.1 coho salmon from a brood year of record-high abundance (2003) suggests relatively poor survival whereas the above-average return of age-1.1 fish from a brood year of above-average abundance (2004) and the below-average return of age-3.1 fish from a brood year of below-average abundance (2002) suggest typical survival.
- Female coho salmon made up approximately 45% of the total annual run. The percentage of female increased slightly as the run progressed.
- The coho salmon run showed length partitioning by sex. Females were larger than males of the same age.
- Mean lengths-at-age of male and female coho salmon were among the smallest on record for this project.
- Female sockeye salmon made up approximately 40% of the total annual run based on the non-ASL sex-determination method, which is near the average of 43% for this project and method.

WEATHER AND STREAM OBSERVATIONS

- For the 2007 season, daily water levels were higher than average at Kogrukluk River weir. Low water conditions occurred in late August and early September and high water conditions occurred in early July through mid August, and again in late September.
- Daily water temperatures at Kogrukluk River weir in 2007 were near average.
- No obvious relationship was observed between fish passage and water level or water temperature.

RECOMMENDATIONS

WEIR OPERATIONS

- Adopt a target operational period (TOP) of 24 June to 20 September. Considerable variability in start and stop dates for the Kogrukluk River weir confound between-year comparisons of summary statistics such as total annual escapement. Circumstances that dictate start and stop dates are often beyond the control of project leaders or crews, but comparability can be enhanced by adopting a TOP across all years. Investigators have been reluctant to adopt a "formal" TOP because weir operations during the 1970s to 1990s were inconsistent in timing, duration, and operational success; one implication of developing a TOP is that escapement within the TOP would need to be determined for each year of weir operation. For most years, this would require that statistically-defensible estimates be calculated for inoperable days within the TOP. Until recently, funding for staff time to pursue this endeavor has not been available. To our benefit, Jim Jasper, a University of Alaska Fairbanks (UAF) graduate student and a former crew leader and author for this report (Jasper and Molyneaux 2007), is currently working to develop estimates to span to TOP for each year of operations. Hopefully, the next project report (expected date of completion in late 2009) will include results from his work.
- Develop a method to estimate the extent of fish "leakage" through the pre-2005 weir design in order to correct previous years' escapement estimates. As weir sections have been replaced over the years, the picket spacing has changed resulting in a weir that incorporated panels of up to 3 different picket widths. The estimation method would require: 1) quantifying the amount of fish leakage through each type of panel, and 2) quantifying the amount of each type of panel in every year's weir design. The former would entail installing older panels into the new weir design and enumerating fish passage through the pickets. The latter may be difficult since the occurrence of stringer changes has been poorly documented. An alternative method may be to examine length frequency histograms for each year to determine the extent to which smaller fish have been excluded from the ASL data. If smaller fish were passing through the pickets to a large degree, one would expect to see a positive skew in the length frequency histograms.

FISH PASSAGE

- Reestablish a SEG for sockeye salmon. The escapement goal of 2,000 sockeye salmon was discontinued around 1995 because sockeye enumeration was considered ancillary and sockeye catch considered incidental (Burkey et al. 1997). In recent years the Kogrukluk River weir has seen record escapements of sockeye salmon and has been concurrent with increased commercial interest in this species among Kuskokwim River commercial fishers and processors. In addition, ongoing large scale sockeye salmon investigations have suggested that the Kogrukluk River supports a considerable portion of the Kuskokwim River sockeye salmon population (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). Escapement goals are essential tools for evaluating the adequacy of salmon escapements to spawning tributaries. The lack of an established sockeye salmon SEG for the Kogrukluk River inhibits sustainable management of this stock. Based on the Bue and Hasbrouck[6] method, we recommend the establishment of a weir-based SEG of 4,200 to 16,000 sockeye salmon. The prescribed SEG rates as excellent based on data quality and quantity. This estimate was generated from 21 years of weir escapement data, each with less than 20% of the total annual escapement estimated. This stock is characterized by a high spawning contrast and a moderate exploitation rate. The prescribed SEG range was rounded up from the 25th to 75th percentiles (4,133 to 15,386 fish) based on rounding convention used for escapement goal recommendation. A SEG was recommended because stock-specific harvest data is lacking, precluding the development of a Biological Escapement Goal (BEG).

SALMON AGE, SEX, AND LENGTH COMPOSITION

- Current pulse sampling goals represent only a 10% increase from those recommended by Bromaghin (1993) to account for illegible or lost scales ("scale loss"). History has proven that scale loss is usually higher. Instead, actual goals should represent a 20% increase over those Bromaghin recommended. Revised goals should be 230 for Chinook salmon, 220 for chum salmon, and 200 for coho salmon (rather than the 210, 200, and 170, respectively, currently in place).
- Objective 2 should be simplified to: "Estimate the age, sex, and length composition of annual Chinook, chum, and coho salmon escapements to the Kogrukluk River weir such that simultaneous 95% confidence intervals of age composition are no wider than 0.20 (α = 0.05, d = 0.10)." As it is currently written, there are 2 clauses that have proven nearly impossible to achieve. First, Chinook salmon should not be among the 3 species for which pulse sampling is required. Second, requirements for *per-pulse* confidence interval width should be omitted from the objective.
- Sampling goals should be revised for Chinook salmon. The goal to sample in 3 pulse samples each composed of 230 fish is impractical in tributaries such as the George River where chum salmon escapement greatly exceeds that of Chinook salmon. In such tributaries it is impossible to sample 230 fish in 3 distinct pulses without greatly inhibiting chum salmon passage. Therefore, sampling goals should be reduced such that the desired confidence interval width of 0.20 would apply to the entire annual escapement but not to individual strata. Consequently, instead of trying to sample a total of 690 fish over 3 pulse samples, investigators should sample a minimum of 230 fish for the entire season. Though one purpose of the pulse sampling design was to ensure fair distribution

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[6] Methods for setting escapement goals from B. G. Bue and J. J. Hasbrouck. *Unpublished*, *Escapement goal review of salmon stocks of Upper Cook Inlet*. Alaska Department of Fish and Game, Report to the Board of Fisheries, Anchorage, 2001.

of the sampling effort, pulse sampling is not necessary to estimate total annual ASL composition as long as sampling effort is fairly well distributed and is conducted in proportion to the run. The annual run can still be stratified and intra-annual changes can still be investigated, but confidence intervals for age composition per strata will generally be broader than what is required by the current Objective 2. Historically, the Chinook salmon confidence interval requirement of Objective 2 has rarely been achieved. Thus, if recommendations described in this paragraph are implemented, it will have little effect on the comparability of historical data.

- In addition to the changes recommended above for Chinook salmon, Objective 2 should be amended as it pertains to all species. As currently worded, the objective requires that confidence intervals for age composition in each pulse be no wider than 0.20. Thus, this objective is not achieved when confidence interval width exceeds 0.20. Since these confidence intervals depend on the size of the sample(s) after ages have been determined, which is a variable that cannot be controlled when sampling, it should not be a requirement of the objective. Desired confidence interval width should be one criterion on which to base sample size goals but it should not influence the success or failure at meeting the objective. In practice, chum and coho sampling can be conducted following the pulse sampling design; large pulse samples increase the resolution
- Weir crews should resume collecting ASL information from Kogrukluk River sockeye salmon. This effort was discontinued in the past because the ability to reliably estimate sockeye salmon age is limited. However, the value of ASL information goes beyond documenting total age information. For instance, sockeye salmon ASL information from this project would provide reliable estimates of annual, and possibly intra-annual, sex ratios and length composition. In addition, scale collection would provide a pool of annual scales that can be used to assess freshwater age and growth. Such information may prove invaluable to managers. This is especially true considering the preliminary results of an ongoing study aimed at describing the biology and ecology of Kuskokwim River sockeye salmon. This study suggests that sockeye salmon spawning throughout the watershed is considerably greater than previously recognized and these stocks display a fairly unique life history strategy for this species (S. E. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication).
- Future project reports for the Kogrukluk River weir should continue and enhance inclusion of detailed figures depicting trends in age, sex, and length composition. Kogrukluk River has the longest history of salmon escapement monitoring in the Kuskokwim Area, but inquiry into the rich history of data collected at this project is elusive because of the limited historical perspective provided by the standard project report. Future project reports for the Kogrukluk River weir should continue to include historical perspectives such as the following:
    - Brood Tables and 3 dimensional graphics that illustrate the number of fish by age class for the recent past,
    - Inter-seasonal differences in sex composition as determined from weighted ASL samples and visual crew counts (both percent and total number),
    - Inter-seasonal trends in the number and percent of females in the escapement,
    - Inter-seasonal trends in average length-at-age and sex.

WEATHER AND STREAM OBSERVATIONS

- Continue monitoring environmental conditions indefinitely. It is clear that environmental stimuli can and do influence migration of Pacific salmon (Quinn 2005). Kuskokwim Area escapement monitoring projects are not specifically designed to evaluate environmental cues to upstream migration, but knowledge of environmental conditions and a commitment to long-term monitoring is valuable to understanding migration and survival of Pacific salmon (Quinn 2005). Even though annual relationships between environmental conditions and salmon migration and abundance are not always clear, long-term data sets may prove valuable to understanding the biology and ecology of these species. We cannot begin to assess the effects of changing environmental conditions on Kuskokwim River salmon without sufficient baseline data consisting of complete and accurate measures of environmental variables. Escapement projects must continue to be diligent in the collection of weather and stream data. Perhaps with sufficient data, researchers and managers will be able to assess relationships between migration and environmental factors relevant in the broader spatial-temporal context.

- Install a remote logging station to record weather data on the Kogrukluk River through the winter. Information could be correlated against future runs to help discern favorable or unfavorable brood conditions for Kogrukluk River salmon stocks. Examples of data that should be collected include, air and water temperature, dissolved oxygen, pH, flow rate, and snow cover. Comparable climatic data loggers could be developed at other weir projects.

- Stream gauging stations should be installed strategically throughout the Holitna basin in order to establish baseline hydrologic data for the purpose of establishing water reservations. ADF&G is charged with the responsibility to "…manage, protect, maintain, improve, and extend the fish, game, and aquatic plant resources of the state in the interest of the economy and general well-being of the state" (AS 16.05.020). Toward this end, Alaskan State law (AS 16.05.050) allows ADF&G to acquire water rights based on data and analysis that substantiates the need for the amount of water being requested (Estes 1996). A water reservation is a legal right (or appropriation of water) to maintain a specific flow rate or level in a given body of water for one or a combination of purposes: 1) protection of fish and wildlife habitat, migration, and propagation; 2) recreation and parks purposes; 3) navigation and transportation purposes; and 4) sanitary and water quality purposes (Estes 1996). Based on the high ecologic and resource value and current and proposed uses of the Holitna watershed, water reservations would be directed at nearly all of the above-mentioned purposes. To date, sufficient hydrologic data for the establishment of water rights on Holitna River, in part or in its entirety, is currently lacking. Multiple gauging stations will likely be needed to adequately describe instream flow characteristics, due to variation in hydrology and geology throughout drainage. We recommend installing a minimum of 3 gauging stations near: 1) the Kogrukluk River weir to describe the upper Holitna; 2) the mouth of the Hoholitna; and 3) the mouth of Holitna near its confluence with the Kuskokwim River.

  In addition, for most readers, the utility in reporting river stage in cm above an arbitrary datum, as determined annually by the crew (see Methods) is limited. Installation of a gauging station combined with the systematic discharge measurements needed for calibration would allow project leaders to convert river stage data to a more meaningful measure of discharge in m^3/sec.

- Cooperate with USFWS OSM in their effort to collect reliable, consistent, and scientifically-defensible baseline data on weather and stream conditions at weir sites. A thermograph was first installed in the Takotna River in 2007 and will continue to be installed annually until battery life expires. If the Takotna River weir crew is selected to assist in this effort, project managers' are willing to add this thermograph to a pool of equipment that is shared among all projects involved.

SPAWNER-RECRUIT ANALYSIS

- Continue to develop a spawner-recruit analysis for Kogrukluk River salmon. One of the caveats in undertaking this initiative in the past was accounting for the unknown fraction of Kogrukluk River fish harvested in the commercial and subsistence fisheries. Preliminary findings from the mark–recapture projects operated in 2002, 2003, and 2004 provide insight into the timing of Kogrukluk River salmon stocks in the lower Kuskokwim River, which may allow for some reasonable assumptions of the temporal fraction of the harvest likely to contain fish bound for the Kogrukluk River. Isolating harvest during that time period and applying an estimated spawning stock apportionment to account for Kogrukluk River fish may provide the resolution required for identifying a reasonable spawner-recruit relationship.

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TABLES AND FIGURES

Table 1.–Daily, cumulative, and cumulative percent passage of Chinook, chum, coho, and sockeye salmon at the Kogrukluk River weir, 2007.

	Chinook			Chum			Coho			Sockeye		
Date	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%	Daily	Cum.	%
6/26[a]	0[b]	0	0	0[b]	0	0	0[c]	0	0	0[b]	0	0
6/27	1	1	0	22	22	0	0	0	0	0	0	0
6/28	1	2	0	15	37	0	0	0	0	0	0	0
6/29	0	2	0	35	72	0	0	0	0	1	1	0
6/30	1	3	0	44	116	0	0	0	0	0	1	0
7/1	14	17	0	104	220	0	0	0	0	1	2	0
7/2	10	27	0	175	395	1	0	0	0	0	2	0
7/3	16	43	0	201	596	1	0	0	0	8	10	0
7/4	117	160	1	453	1,049	2	0	0	0	15	25	0
7/5	28	188	1	320	1,369	3	0	0	0	14	39	0
7/6	35	223	2	422	1,791	4	0	0	0	6	45	0
7/7	71	294	2	754	2,545	5	0	0	0	31	76	0
7/8	362	656	5	895	3,440	7	0	0	0	85	161	1
7/9	679	1,335	10	1,308	4,748	10	0	0	0	151	312	2
7/10	464	1,799	14	1,721	6,469	13	0	0	0	197	509	3
7/11[a]	593[d]	2,392	18	1,664[d]	8,133	16	0[d]	0	0	272[d]	781	5
7/12[a]	614[d]	3,005	23	1,813[d]	9,945	20	0[d]	0	0	369[d]	1,150	7
7/13[a]	635[d]	3,640	28	1,962[d]	11,907	24	0[d]	0	0	467[d]	1,616	10
7/14[a]	656[d]	4,295	33	2,111[d]	14,017	28	0[d]	0	0	564[d]	2,180	13
7/15[a]	677[d]	4,972	38	2,260[d]	16,277	33	0[d]	0	0	662[d]	2,842	17
7/16[a]	698[d]	5,669	44	2,409[d]	18,685	38	0[d]	0	0	759[d]	3,601	22
7/17[a]	719[d]	6,388	49	2,558[d]	21,243	43	0[d]	0	0	857[d]	4,457	27
7/18	725	7,113	55	2,921	24,164	49	0	0	0	1,052	5,509	33
7/19	754	7,867	60	2,492	26,656	54	0	0	0	856	6,365	39
7/20[a]	640[d]	8,506	65	1,280[d]	27,935	56	0[d]	0	0	833[d]	7,198	44
7/21[a]	540[d]	9,046	69	1,313[d]	29,248	59	1[d]	1	0	712[d]	7,910	48
7/22[a]	440[d]	9,485	73	1,347[d]	30,595	62	1[d]	2	0	591[d]	8,502	51
7/23	379	9,864	76	1,840	32,435	66	0	2	0	423	8,925	54
7/24	300	10,164	78	920	33,355	67	2	4	0	518	9,443	57
7/25	341	10,505	81	712	34,067	69	0	4	0	737	10,180	62
7/26	483	10,988	84	1,751	35,818	72	7	11	0	1,074	11,254	68
7/27	350	11,338	87	1,630	37,448	76	5	16	0	749	12,003	73
7/28	250	11,588	89	1,619	39,067	79	6	22	0	632	12,635	76
7/29	357	11,945	92	1,703	40,770	82	7	29	0	862	13,497	82
7/30	139	12,084	93	1,692	42,462	86	17	46	0	619	14,116	85
7/31	53	12,137	93	407	42,869	87	6	52	0	286	14,402	87
8/1	54	12,191	94	186	43,055	87	15	67	0	313	14,715	89
8/2	96	12,287	94	220	43,275	87	23	90	0	263	14,978	91
8/3	142	12,429	95	437	43,712	88	40	130	0	194	15,172	92
8/4[a]	104[d]	12,533	96	375[d]	44,087	89	45[d]	174	1	200[d]	15,372	93
8/5[a]	89[d]	12,622	97	422[d]	44,509	90	58[d]	233	1	172[d]	15,544	94
8/6[a]	74[d]	12,696	97	469[d]	44,978	91	72[d]	304	1	143[d]	15,687	95
8/7[a]	59[d]	12,755	98	516[d]	45,495	92	85[d]	390	1	115[d]	15,802	96
8/8	54	12,809	98	682	46,177	93	79	469	2	87	15,889	96
8/9	34	12,843	99	444	46,621	94	118	587	2	86	15,975	97
8/10	29	12,872	99	424	47,045	95	91	678	3	96	16,071	97
8/11	17	12,889	99	312	47,357	96	51	729	3	74	16,145	98

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Table 1.–Page 2 of 2.

Date	Chinook Daily	Chinook Cum.	Chinook %	Chum Daily	Chum Cum.	Chum %	Coho Daily	Coho Cum.	Coho %	Sockeye Daily	Sockeye Cum.	Sockeye %
8/12	28	12,917	99	445	47,802	97	287	1,016	4	85	16,230	98
8/13	23	12,940	99	311	48,113	97	422	1,438	5	78	16,308	99
8/14	18	12,958	99	204	48,317	98	337	1,775	7	36	16,344	99
8/15	5	12,963	99	187	48,504	98	153	1,928	7	34	16,378	99
8/16	7	12,970	100	157	48,661	98	333	2,261	8	23	16,401	99
8/17	10	12,980	100	138	48,799	99	329	2,590	10	21	16,422	99
8/18	6	12,986	100	83	48,882	99	270	2,860	11	11	16,433	99
8/19	4	12,990	100	98	48,980	99	361	3,221	12	16	16,449	100
8/20	4	12,994	100	79	49,059	99	715	3,936	15	14	16,463	100
8/21	7	13,001	100	75	49,134	99	553	4,489	17	10	16,473	100
8/22	5	13,006	100	72	49,206	99	1,152	5,641	21	8	16,481	100
8/23	5	13,011	100	51	49,257	99	1,468	7,109	26	8	16,489	100
8/24	5	13,016	100	44	49,301	100	1,137	8,246	31	4	16,493	100
8/25	3	13,019	100	31	49,332	100	1,698	9,944	37	6	16,499	100
8/26	4	13,023	100	23	49,355	100	799	10,743	40	2	16,501	100
8/27	1	13,024	100	16	49,371	100	811	11,554	43	2	16,503	100
8/28	1	13,025	100	16	49,387	100	1,293	12,847	48	0	16,503	100
8/29	0	13,025	100	12	49,399	100	1,490	14,337	53	1	16,504	100
8/30	1	13,026	100	11	49,410	100	772	15,109	56	3	16,507	100
8/31	1	13,027	100	5	49,415	100	910	16,019	59	1	16,508	100
9/1	0	13,027	100	12	49,427	100	1,185	17,204	64	2	16,510	100
9/2	0	13,027	100	7	49,434	100	1,009	18,213	67	0	16,510	100
9/3	1	13,028	100	8	49,442	100	838	19,051	70	1	16,511	100
9/4	0	13,028	100	3	49,445	100	931	19,982	74	0	16,511	100
9/5	0	13,028	100	4	49,449	100	1,153	21,135	78	2	16,513	100
9/6	1	13,029	100	6	49,455	100	560	21,695	80	1	16,514	100
9/7	0	13,029	100	2	49,457	100	563	22,258	82	1	16,515	100
9/8	0	13,029	100	2	49,459	100	667	22,925	85	0	16,515	100
9/9[a]	0[d]	13,029	100	2[d]	49,461	100	563[d]	23,488	87	1[d]	16,515	100
9/10[a]	0[d]	13,029	100	2[d]	49,463	100	512[d]	23,999	89	1[d]	16,516	100
9/11[a]	0[d]	13,029	100	3[d]	49,466	100	460[d]	24,459	90	1[d]	16,517	100
9/12[a]	0[d]	13,029	100	3[d]	49,468	100	408[d]	24,868	92	1[d]	16,518	100
9/13[a]	0[d]	13,029	100	3[d]	49,471	100	357[d]	25,224	93	1[d]	16,519	100
9/14[a]	0[d]	13,029	100	3[d]	49,474	100	305[d]	25,529	94	1[d]	16,520	100
9/15[a]	0[d]	13,029	100	3[d]	49,478	100	253[d]	25,782	95	1[d]	16,522	100
9/16	0	13,029	100	1	49,479	100	209	25,991	96	3	16,525	100
9/17	0	13,029	100	6	49,485	100	194	26,185	97	0	16,525	100
9/18	0	13,029	100	2	49,487	100	163	26,348	97	0	16,525	100
9/19[a]	0[d]	13,029	100	4[d]	49,491	100	164[d]	26,512	98	0[d]	16,525	100
9/20[a]	0[d]	13,029	100	4[d]	49,494	100	149[d]	26,661	99	0[d]	16,525	100
9/21[a]	0[d]	13,029	100	4[d]	49,498	100	134[d]	26,795	99	0[d]	16,525	100
9/22	0	13,029	100	4	49,502	100	118	26,913	100	0	16,525	100
9/23	0	13,029	100	3	49,505	100	120	27,033	100	0	16,525	100

[a] The weir was inoperable for all or part of the day.
[b] Incomplete or partial daily count.
[c] Daily passage was assumed zero based on historical run timing data.
[d] Daily passage was estimated using the "linear interpolation" method.

Table 2.–Age and sex composition of Chinook salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

			Age Class																	
Sample Dates	Sample		1.1		1.2		1.3		2.2		1.4		2.3		1.5		2.4		Total	
(Stratum Dates)	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
7/2-10	97	M	0	0.0	1,550	36.1	1,771	41.2	0	0.0	354	8.3	0	0.0	45	1.1	0	0.0	3,719	86.6
(6/26-7/14)		F	0	0.0	0	0.0	89	2.1	0	0.0	443	10.3	0	0.0	44	1.0	0	0.0	576	13.4
		Subtotal[a]	0	0.0	1,550	36.1	1,860	43.3	0	0.0	797	18.6	0	0.0	89	2.1	0	0.0	4,295	100.0
7/18-26	104	M	0	0.0	2,059	30.8	1,352	20.2	0	0.0	965	14.4	0	0.0	0	0.0	0	0.0	4,376	65.4
(7/15-26)		F	0	0.0	0	0.0	579	8.6	0	0.0	1,609	24.1	0	0.0	129	1.9	0	0.0	2,317	34.6
		Subtotal[a]	0	0.0	2,059	30.8	1,931	28.8	0	0.0	2,574	38.5	0	0.0	129	1.9	0	0.0	6,693	100.0
7/27-31	88	M	0	0.0	603	29.5	301	14.8	0	0.0	278	13.6	0	0.0	46	2.3	0	0.0	1,229	60.2
(7/27-9/23)		F	0	0.0	0	0.0	209	10.2	0	0.0	487	23.9	0	0.0	116	5.7	0	0.0	812	39.8
		Subtotal[a]	0	0.0	603	29.5	510	25.0	0	0.0	765	37.5	0	0.0	162	8.0	0	0.0	2,041	100.0
Season[b]	289	M	0	0.0	4,212	32.3	3,424	26.3	0	0.0	1,598	12.2	0	0.0	91	0.7	0	0.0	9,325	71.6
		F	0	0.0	0	0.0	877	6.7	0	0.0	2,539	19.5	0	0.0	289	2.2	0	0.0	3,704	28.4
		Total	0	0.0	4,212	32.3	4,301	33.0	0	0.0	4,137	31.7	0	0.0	380	2.9	0	0.0	13,029	100.0

[a] The number of fish in each stratum age and sex category are derived from the sample percentages; discrepancies in sums are attributed to rounding errors.

[b] The number of fish in "Season" summaries are the strata sums; "Season" percentages are derived from the sums of the estimated escapement that occurred in each stratum.

Table 3.–Mean length (mm) of Chinook salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4
7/2-10 (6/26-7/14)	M	Mean Length		539	678		730		842	
		SE		8	10		29		-	
		Range		442- 645	516- 818		586- 823		842- 842	
		Sample Size	0	35	40	0	8	0	1	0
	F	Mean Length			801		845		840	
		SE			2		19		-	
		Range			799- 803		724- 924		840- 840	
		Sample Size	0	0	2	0	10	0	1	0
7/18-26 (7/15-26)	M	Mean Length		550	695		805			
		SE		6	16		26			
		Range		459- 632	566- 858		609- 998			
		Sample Size	0	32	21	0	15	0	0	0
	F	Mean Length			782		866		864	
		SE			11		13		79	
		Range			750- 857		723- 969		785- 942	
		Sample Size	0	0	9	0	25	0	2	0
7/27-31 (7/27-9/23)	M	Mean Length		549	683		767		769	
		SE		10	14		28		29	
		Range		436- 683	605- 750		654- 986		740- 797	
		Sample Size	0	26	13	0	12	0	2	0
	F	Mean Length			799		869		842	
		SE			15		12		25	
		Range			724- 883		757- 951		766- 888	
		Sample Size	0	0	9	0	21	0	5	0
Season[a]	M	Mean Length		546	685		781		804	
		Range		436- 683	516- 858		586- 998		740- 842	
		Sample Size	0	93	74	0	35	0	3	0
	F	Mean Length			788		863		851	
		Range			724- 883		723- 969		766- 942	
		Sample Size	0	0	20	0	56	0	8	0

Note: The sum of the sample sizes in each stratum equal the total sample size reported for that stratum in Table 2.

[a] "Season" mean lengths are weighted by the escapement passage in each stratum.

Table 4.–Age and sex composition of chum salmon at the Kogrukluk River in 2007 weir based on escapement samples collected with a live trap.

			Age Class									
Sample Dates	Sample		0.2		0.3		0.4		0.5		Total	
(Stratum Dates)	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
7/2-6	187	M	0	0.0	680	26.7	912	35.8	191	7.5	1,783	70.1
(6/26-7/7)		F	14	0.5	259	10.2	422	16.6	68	2.7	762	29.9
		Subtotal[a]	14	0.5	939	36.9	1,334	52.4	259	10.2	2,545	100.0
7/9-10,18-19	196	M	0	0.0	8,855	33.2	6,131	23.0	818	3.1	15,804	59.2
(7/8-21)		F	681	2.6	6,676	25.0	3,406	12.7	136	0.5	10,899	40.8
		Subtotal[a]	681	2.6	15,531	58.2	9,537	35.7	954	3.6	26,703	100.0
7/23-28	173	M	0	0.0	4,995	43.3	2,198	19.1	266	2.3	7,459	64.7
(7/22-29)		F	200	1.7	2,864	24.9	999	8.6	0	0.0	4,063	35.3
		Subtotal[a]	200	1.7	7,859	68.2	3,197	27.7	266	2.3	11,522	100.0
7/30-31	84	M	208	2.4	3,328	38.1	2,288	26.2	0	0.0	5,824	66.7
(7/30-9/23)		F	312	3.6	1,664	19.0	936	10.7	0	0.0	2,912	33.3
		Subtotal[a]	520	6.0	4,992	57.1	3,224	36.9	0	0.0	8,736	100.0
Season[b]	640	M	208	0.4	17,859	36.1	11,528	23.3	1,275	2.6	30,870	62.4
		F	1,207	2.5	11,462	23.1	5,763	11.6	204	0.4	18,635	37.6
		Total	1,415	2.9	29,321	59.2	17,291	34.9	1,479	3.0	49,505	100.0

[a] The number of fish in each stratum age and sex category are derived from the sample percentages; discrepancies in sums are attributed to rounding errors.

[b] The number of fish in "Season" summaries are the strata sums; "Season" percentages are derived from the sums of the estimated escapement that occurred in each stratum.

Table 5.–Mean length (mm) of chum salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 0.2	0.3	0.4	0.5
7/2-6 (6/26-7/7)	M	Mean Length		566	583	592
		SE		5	3	7
		Range		492- 657	510- 654	534- 632
		Sample Size	0	50	67	14
	F	Mean Length	512	536	549	569
		SE	-	6	5	8
		Range	512- 512	487- 594	494- 606	553- 598
		Sample Size	1	19	31	5
7/9-10,18-19 (7/8-21)	M	Mean Length		556	571	583
		SE		3	5	12
		Range		493- 617	515- 640	541- 615
		Sample Size	0	65	45	6
	F	Mean Length	501	541	548	571
		SE	7	3	6	-
		Range	488- 522	483- 588	490- 606	571- 571
		Sample Size	5	49	25	1
7/23-28 (7/22-29)	M	Mean Length		549	570	591
		SE		3	5	3
		Range		492- 613	516- 617	586- 599
		Sample Size	0	75	33	4
	F	Mean Length	519	543	554	
		SE	9	3	6	
		Range	506- 536	500- 586	508- 596	
		Sample Size	3	43	15	0
7/30-31 (7/30-9/23)	M	Mean Length	515	551	559	
		SE	21	4	9	
		Range	494- 535	494- 608	482- 680	
		Sample Size	2	32	22	0
	F	Mean Length	528	545	542	
		SE	7	7	8	
		Range	521- 543	481- 581	506- 596	
		Sample Size	3	16	9	0
Season[a]	M	Mean Length	515	553	570	586
		Range	494- 535	492- 657	482- 680	534- 632
		Sample Size	2	222	167	24
	F	Mean Length	511	542	548	570
		Range	488- 543	481- 594	490- 606	553- 598
		Sample Size	12	127	80	6

Note: The sum of the sample sizes in each stratum equal the total sample size reported for that stratum in Table 4.

[a] "Season" mean lengths are weighted by the escapement passage in each stratum.

Table 6.–Age and sex composition of coho salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

			Age Class							
			1.1		2.1		3.1		Total	
Sample Dates (Stratum Dates)	Sample Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%
8/20-22	135	M	515	5.2	6,335	63.7	295	2.9	7,145	71.9
(6/26-8/25)		F	74	0.7	2,578	25.9	147	1.5	2,799	28.1
		Subtotal[a]	589	5.9	8,913	89.6	442	4.4	9,944	100.0
8/30-9/1	147	M	229	2.0	4,948	44.2	229	2.0	5,405	48.3
(8/26-9/5)		F	76	0.7	5,558	49.7	152	1.4	5,786	51.7
		Subtotal[a]	305	2.7	10,506	93.9	381	3.4	11,191	100.0
9/8,16-18	112	M	53	0.9	2,159	36.6	211	3.6	2,422	41.1
(9/6-23)		F	0	0.0	2,949	50.0	526	8.9	3,476	58.9
		Subtotal[a]	53	0.9	5,108	86.6	737	12.5	5,898	100.0
Season[b]	394	M	796	2.9	13,442	49.7	734	2.7	14,973	55.4
		F	150	0.6	11,085	41.0	826	3.1	12,060	44.6
		Total	946	3.5	24,527	90.7	1,560	5.8	27,033	100.0

[a] The number of fish in each stratum age and sex category are derived from the sample percentages; discrepancies in sums are attributed to rounding errors.

[b] The number of fish in "Season" summaries are the strata sums; "Season" percentages are derived from the sums of the estimated escapement that occurred in each stratum.

Table 7.–Mean Length (mm) of coho salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

Sample Dates (Stratum Dates)	Sex		Age Class 1.1	2.1	3.1
8/20-22 (6/26-8/25)	M	Mean Length	539	541	504
		SE	17	4	34
		Range	460- 586	408- 644	404- 549
		Sample Size	7	86	4
	F	Mean Length	549	552	539
		SE	-	5	17
		Range	549- 549	465- 604	522- 555
		Sample Size	1	35	2
8/30-9/1 (8/26-9/5)	M	Mean Length	502	531	532
		SE	27	6	22
		Range	456- 548	402- 632	489- 565
		Sample Size	3	65	3
	F	Mean Length	549	549	570
		SE	-	4	4
		Range	549- 549	402- 651	566- 573
		Sample Size	1	73	2
9/8,16-18 (9/6-23)	M	Mean Length	528	535	537
		SE	-	6	22
		Range	528- 528	422- 597	497- 586
		Sample Size	1	41	4
	F	Mean Length		553	553
		SE		4	8
		Range		455- 619	509- 606
		Sample Size	0	56	10
Season[a]	M	Mean Length	527	536	522
		Range	456- 586	402- 644	404- 586
		Sample Size	11	192	11
	F	Mean Length	549	551	553
		Range	549- 549	402- 651	509- 606
		Sample Size	2	164	14

Note: The sum of the sample sizes in each stratum equal the total sample size reported for that stratum in Table 6.

[a] "Season" mean lengths are weighted by the escapement passage in each stratum.

Table 8.–Age and sex composition of sockeye salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

			Age Class																	
	Sample		0.2		0.3		1.2		0.4		1.3		2.2		1.4		2.3		Total	
Sample Dates	Size	Sex	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%	Esc.	%
7/23-8/2	167	M	0	0.0	0	0.0	8,015	48.5	0	0.0	1,682	10.2	198	1.2	0	0.0	99	0.6	9,994	60.5
		F	0	0.0	99	0.6	4,849	29.3	0	0.0	1,484	9.0	0	0.0	0	0.0	99	0.6	6,531	39.5
		Total	0	0.0	99	0.6	12,864	77.8	0	0.0	3,166	19.2	198	1.2	0	0.0	198	1.2	16,525	100.0

Note: Whether these estimates are representative of the entire season will be discussed in the text. No assertions to that effect are made here.

Table 9.–Mean length (mm) of sockeye salmon at the Kogrukluk River weir in 2007 based on escapement samples collected with a live trap.

			Age Class							
Sample Dates	Sex		0.2	0.3	1.2	0.4	1.3	2.2	1.4	2.3
7/23-8/2	M	Mean Length			577		593	582		606
		Range			516- 631		530- 626	565- 598		606- 606
		Sample Size	0	0	81	0	17	2	0	1
	F	Mean Length		543	536		548			540
		Range		543- 543	480- 571		524- 582			540- 540
		Sample Size	0	1	49	0	15	0	0	1

Note: Whether these estimates are representative of the entire season will be discussed in the text. No assertions to that effect are made here.

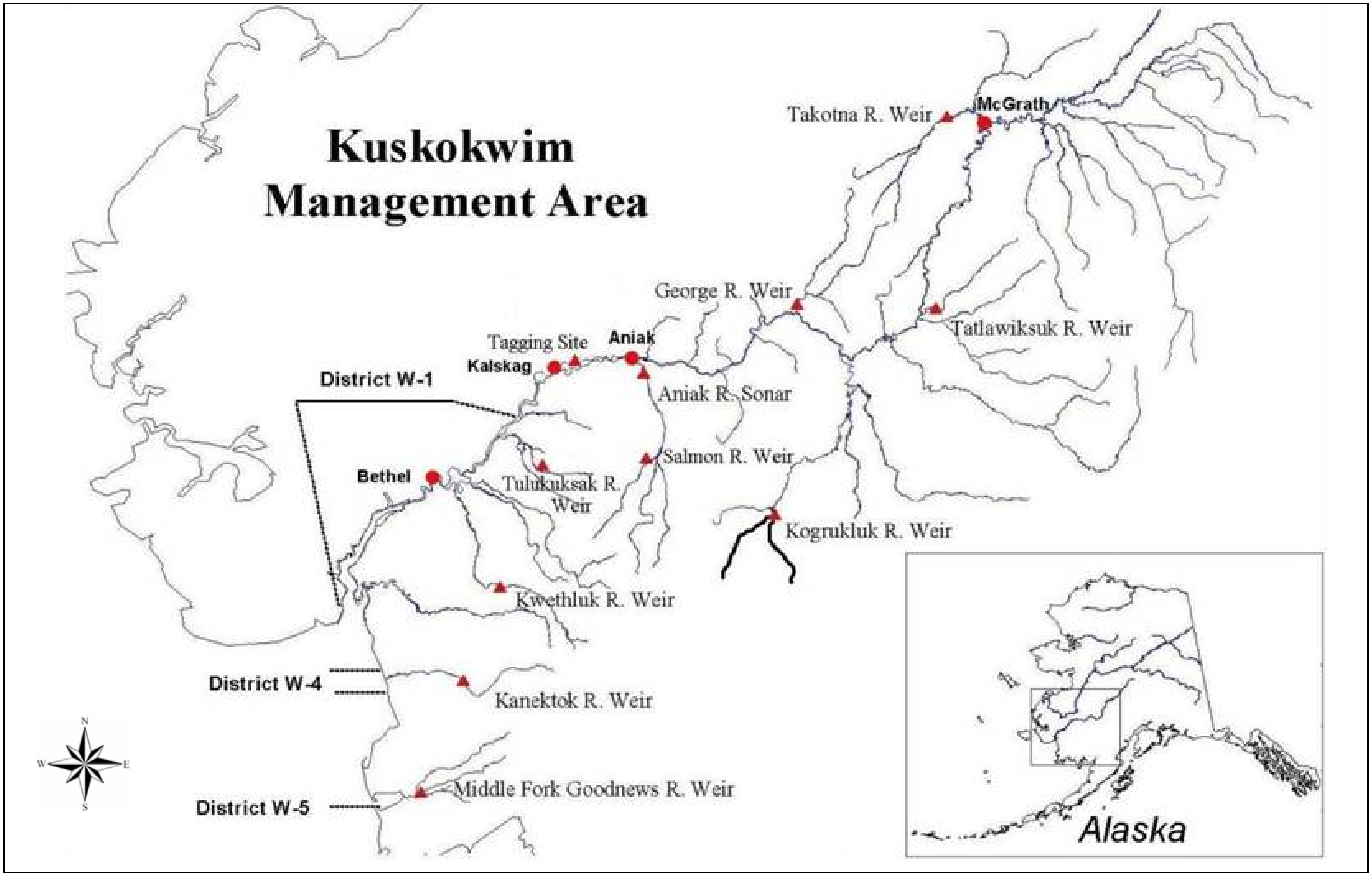


Figure 1.–Kuskokwim Area salmon management districts and escapement monitoring projects with emphasis on the Kogrukluk River.

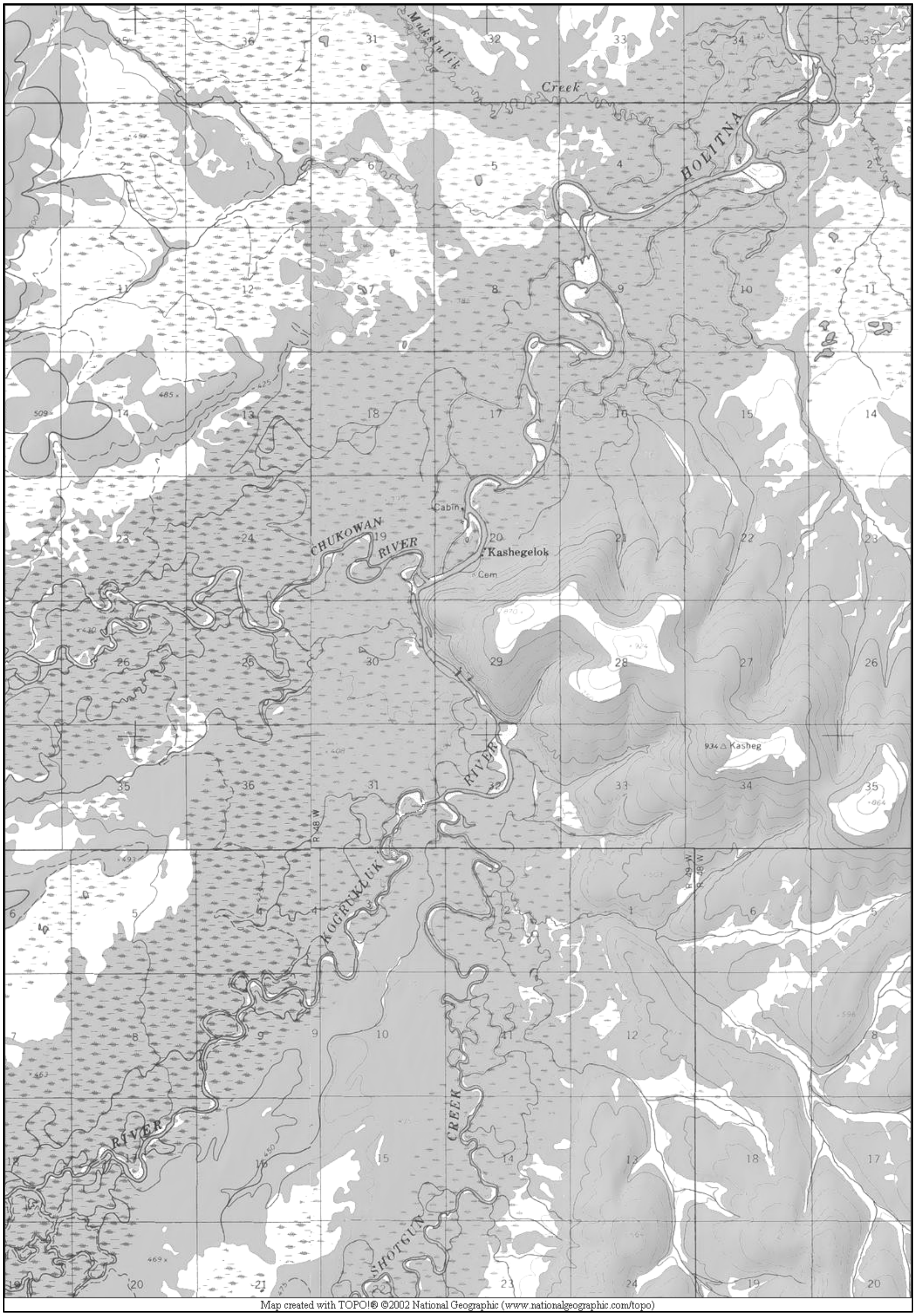


Figure 2.–Kogrukluk River study area and location of historical escapement monitoring projects.

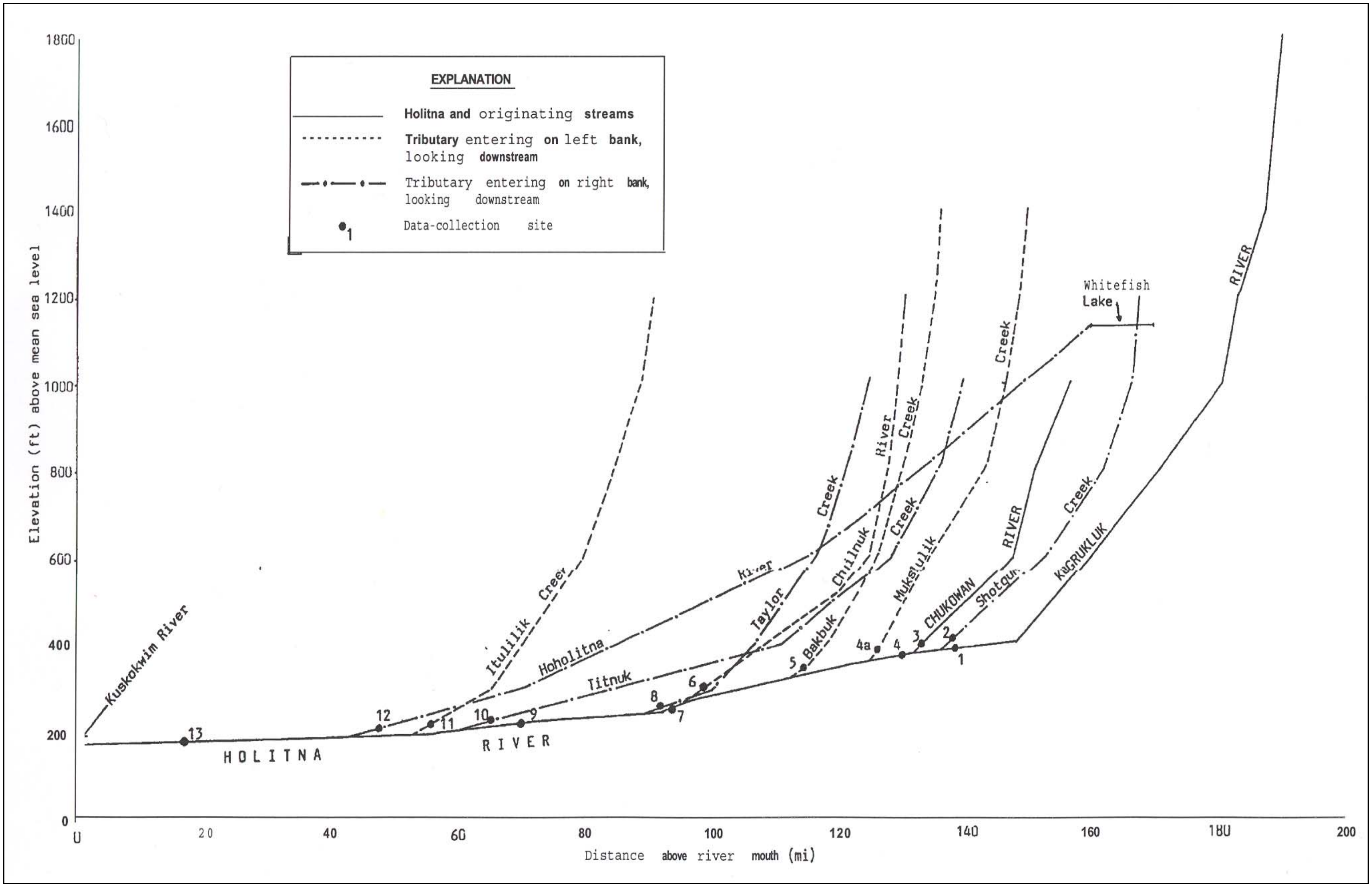
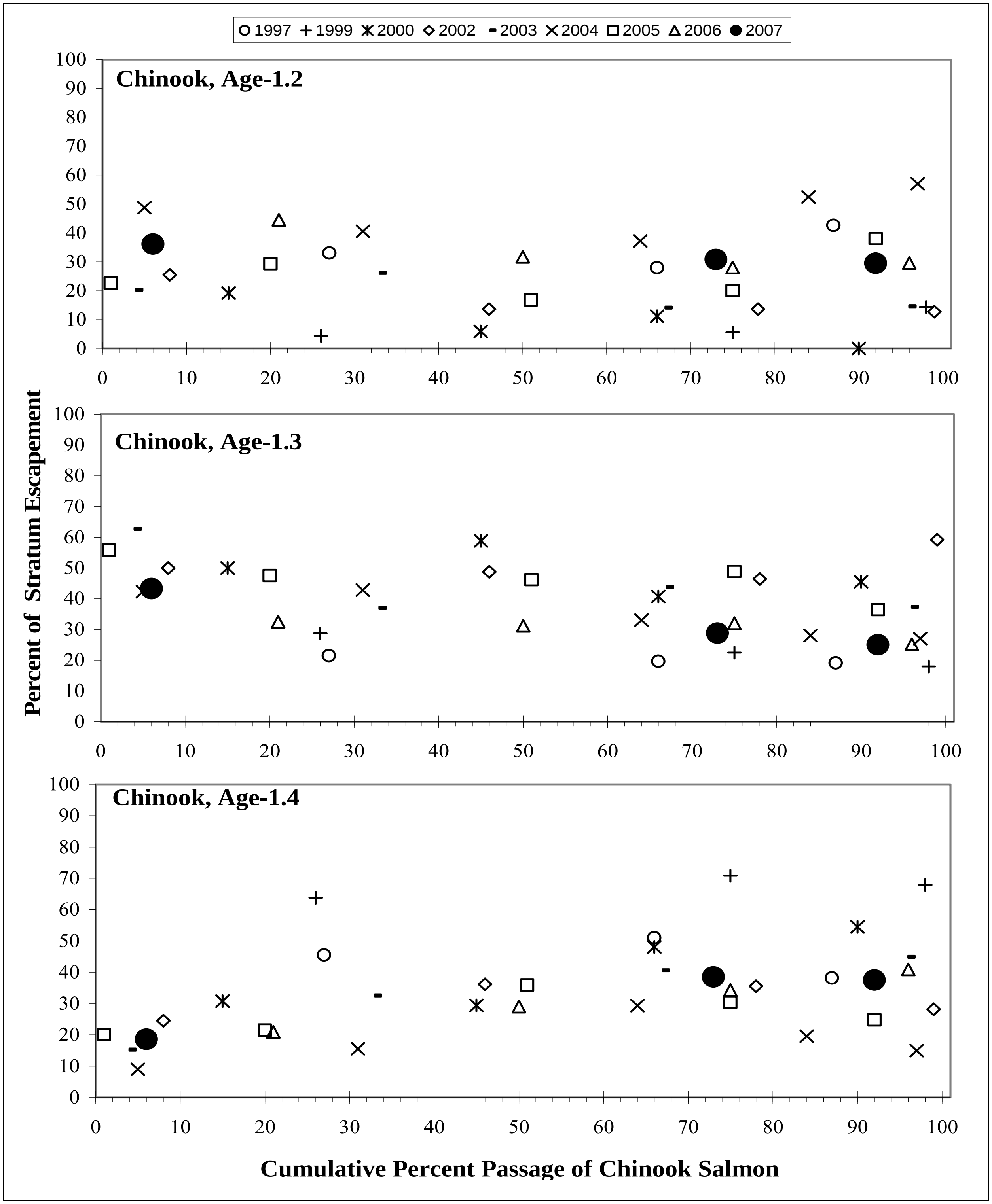
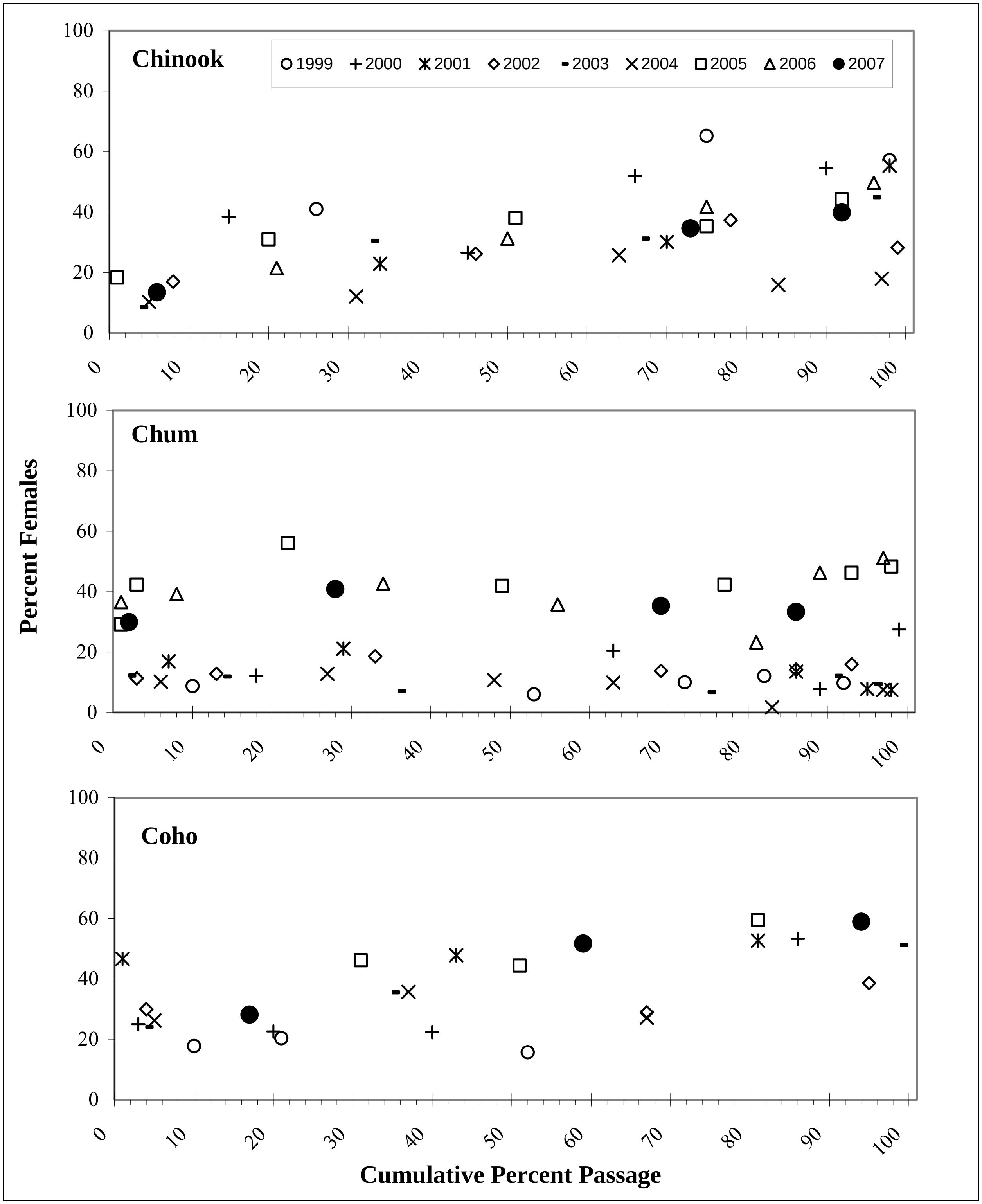


Figure 3.–Profile of the Holitna River and major tributary.



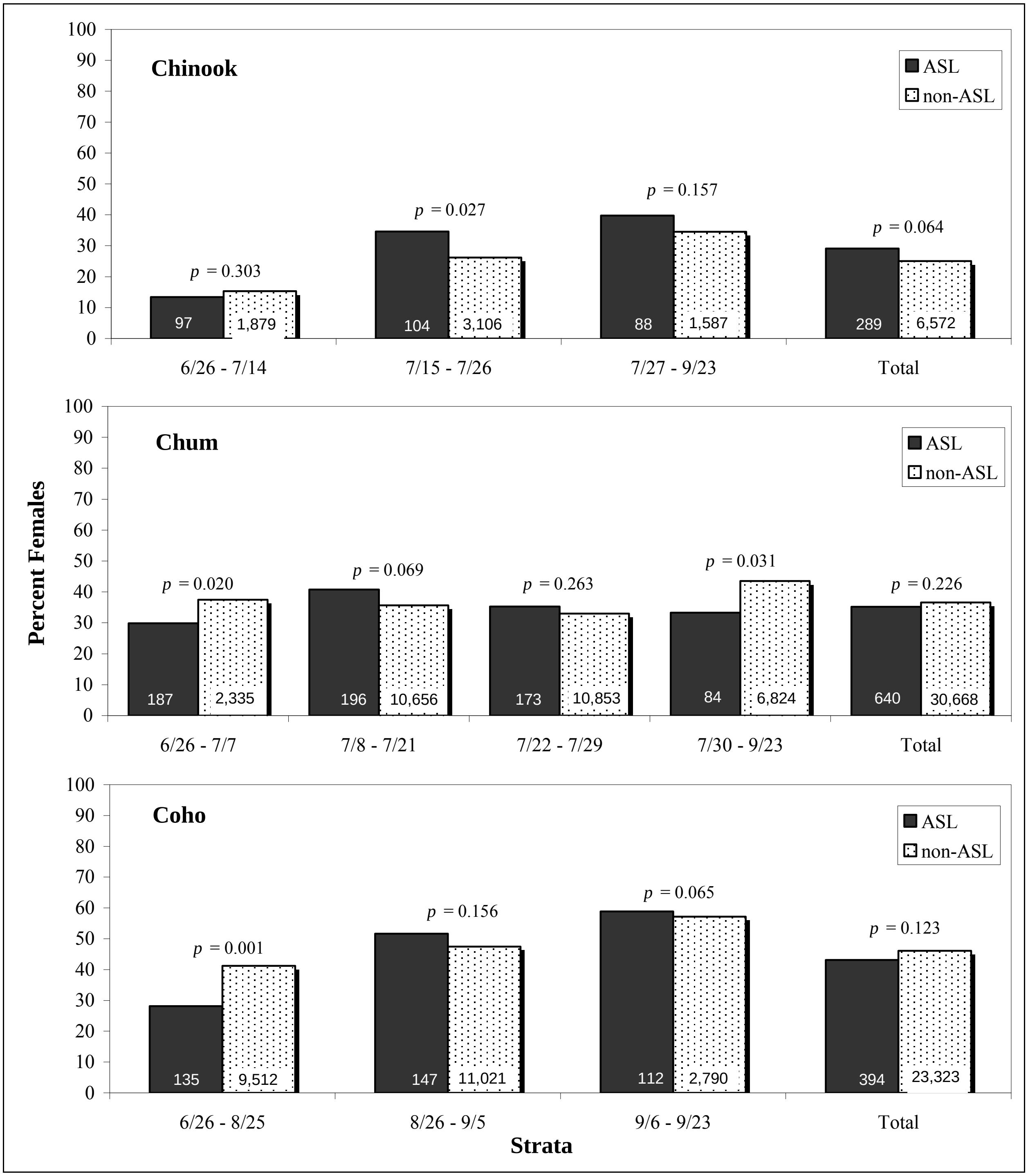
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification. For the purposes of discussion, 2007 was included despite the high percentage of estimated passage.

Figure 4.–Historical Chinook salmon age composition by cumulative percent passage at the Kogrukluk River weir.



Note: Years were omitted when annual escapement contained passage estimates greater than 20% and/or sample sizes were not large enough for temporal stratification. For the purposes of discussion, 2007 Chinook and chum salmon were included despite the high percentage of estimated passage.

Figure 5.–Historical percentage of female Chinook, chum, and coho salmon by cumulative percent passage at the Kogrukluk River weir.



Note: The number above each pair of columns is a z-test derived p-value (p), and the number at the base of each column is sample size.

Figure 6.–Daily Comparison of the percentage of female salmon passing upstream of the Kogrukluk River weir in 2007 as determined from standard ASL sampling using a fish trap, and from visual inspection of non-ASL sampled fish using standard fish passage procedures .

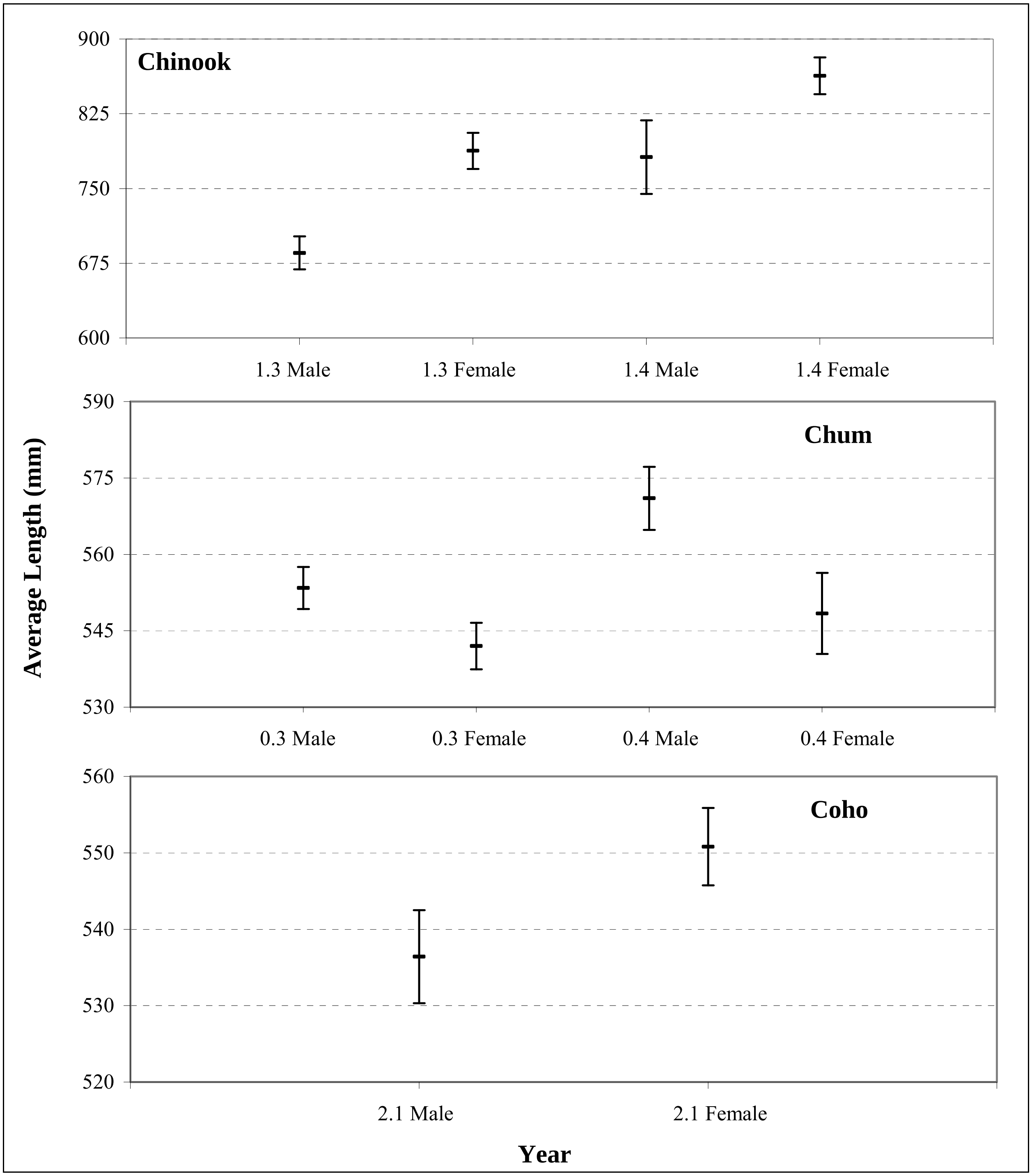
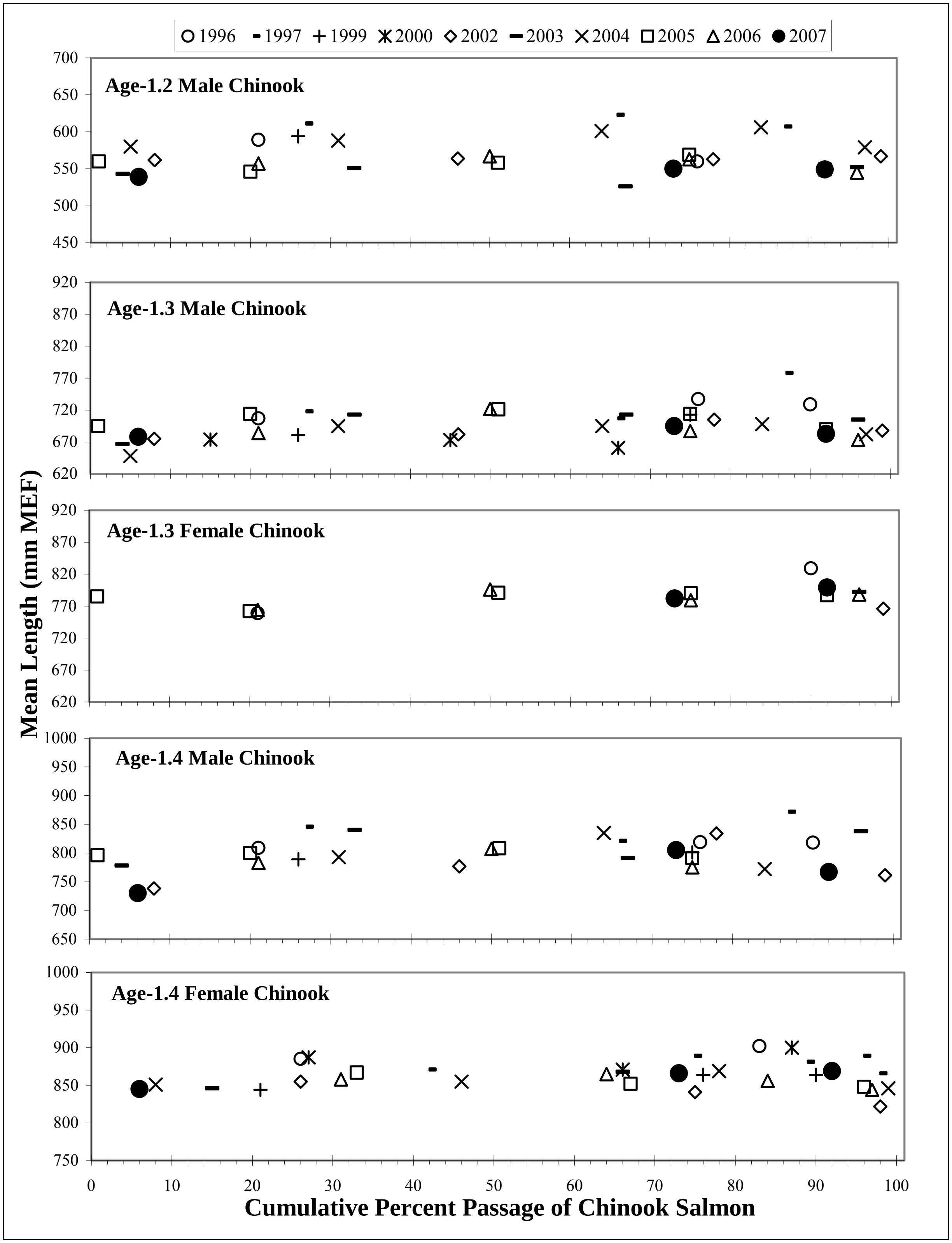
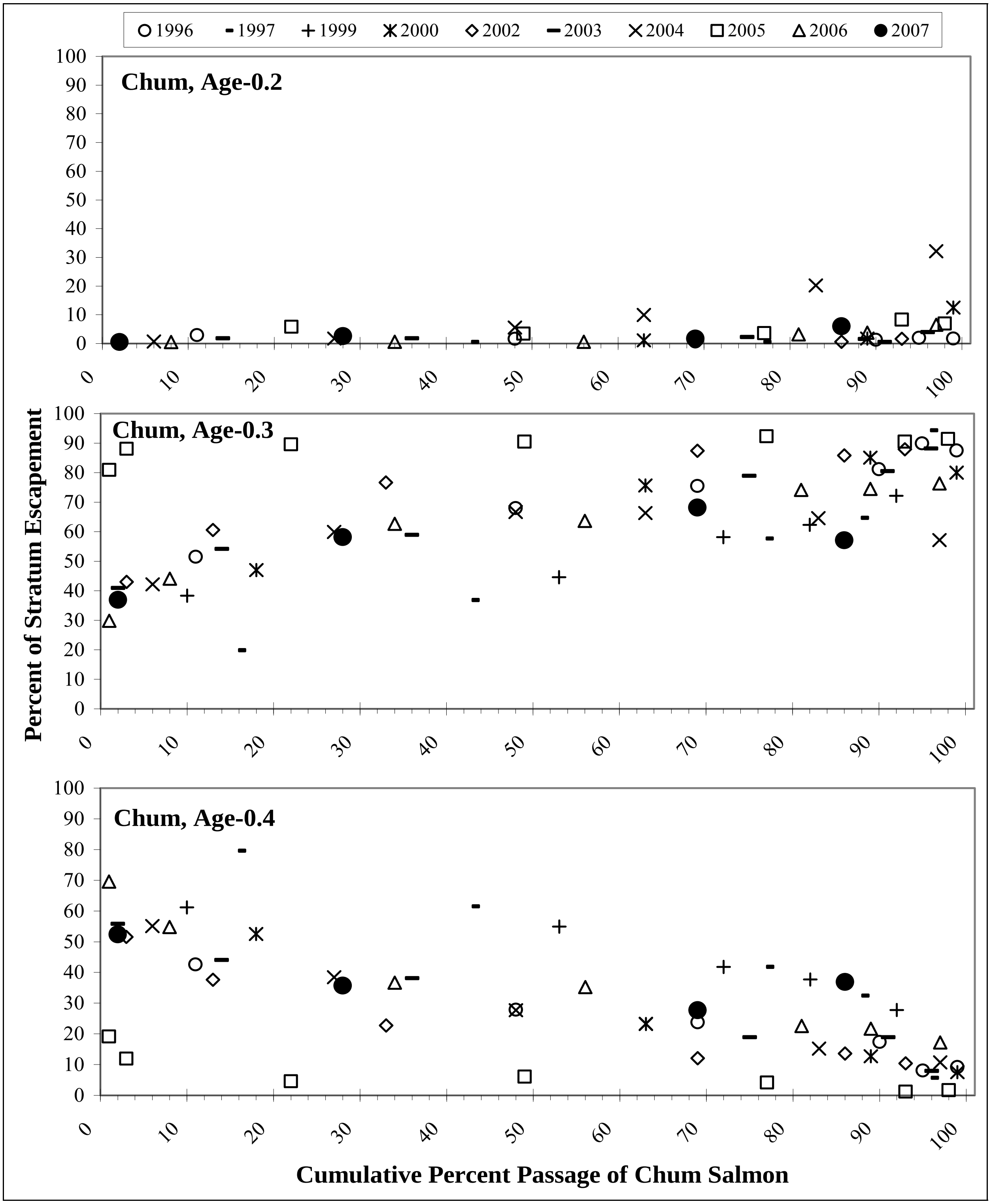


Figure 7.–Average length of Chinook, chum, and coho salmon by age and sex at the Kogrukluk River weir with 95% confidence intervals.



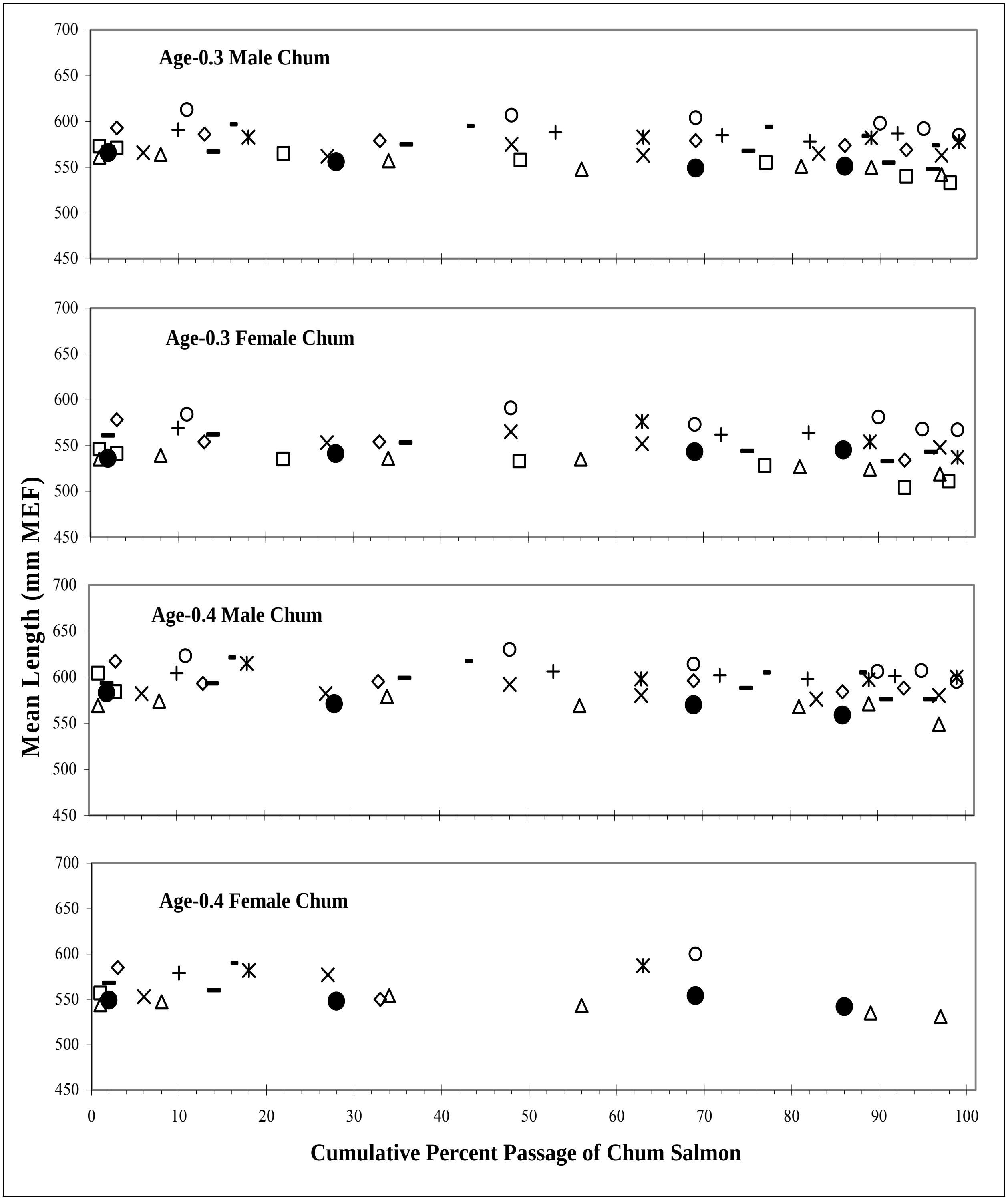
Note: The only sample sizes greater than 6 fish were included in this figure.

Figure 8.–Historical intra-annual mean length at age of male and female Chinook salmon by cumulative percent passage at Kogrukluk River weir.



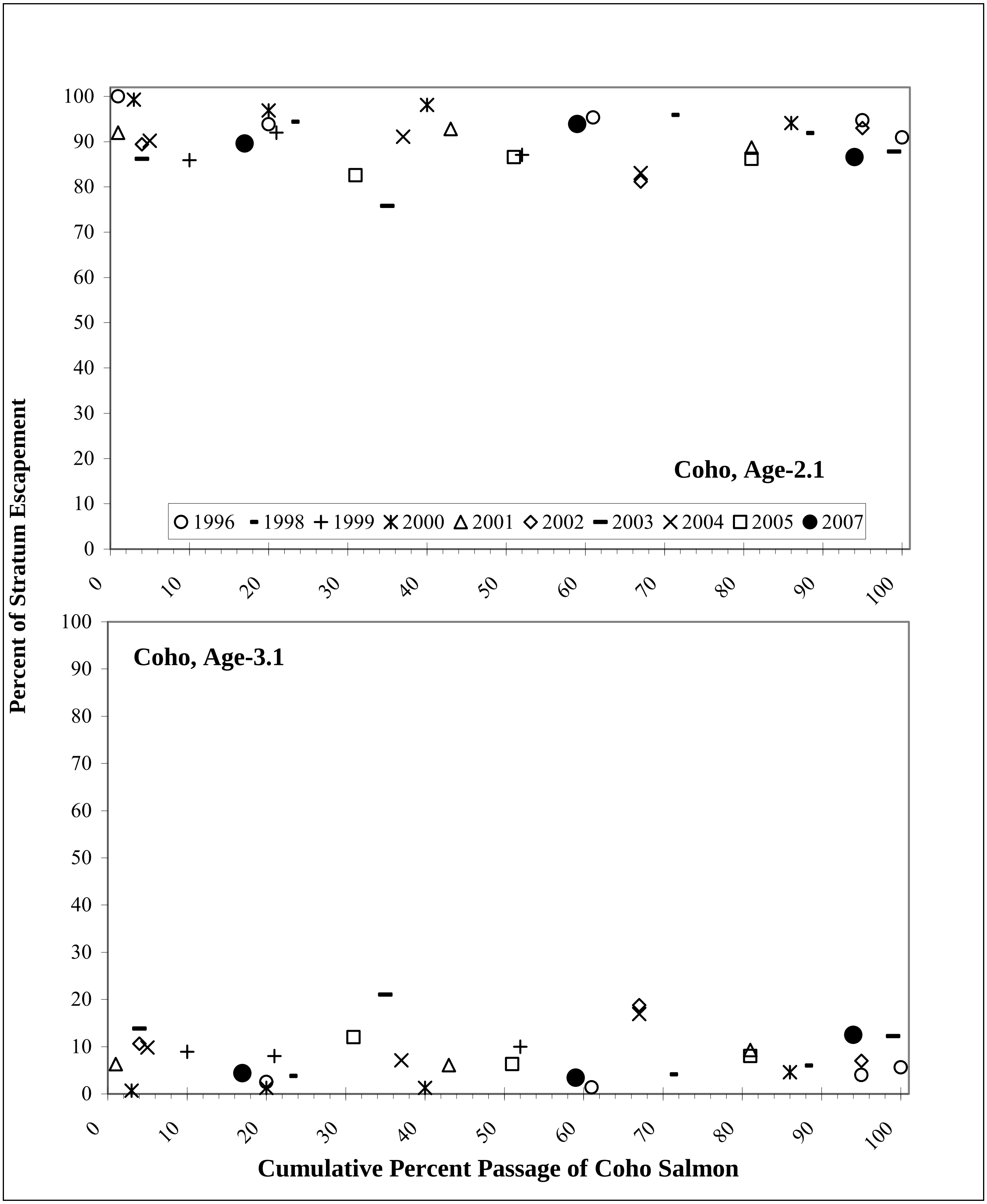
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification. For the purposes of discussion, 2007 was included despite the high percentage of estimated passage.

Figure 9.–Historical chum salmon age composition by cumulative percent passage at Kogrukluk River weir.



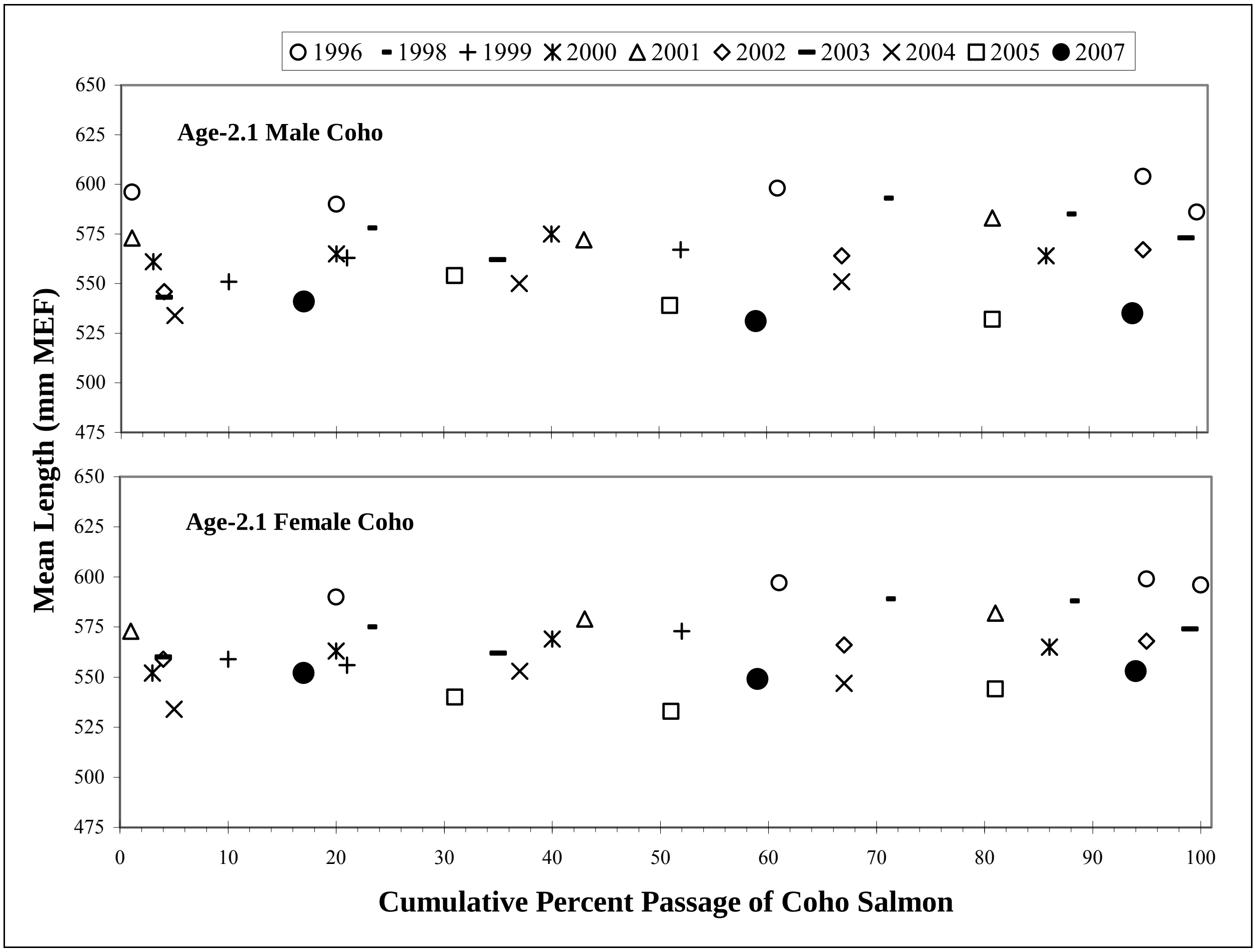
Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification. Only means from samples greater than 6 fish were included in this figure. For the purpose of discussion, 2007 was included in this figure despite the high percentage of estimated passage.

Figure 10.–Historical intra-annual mean length at age of male and female chum salmon by cumulative percent passage at the Kogrukluk River weir.



Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 11.–Historical coho salmon age composition by cumulative percent passage at the Kogrukluk River weir.



Note: Years were omitted when annual escapement contained considerable passage estimates (greater than 20%) and/or sample sizes were not large enough for temporal stratification.

Figure 12.–Historical intra-annual mean length at age of male and female coho salmon by cumulative percent passage at the Kogrukluk River weir.

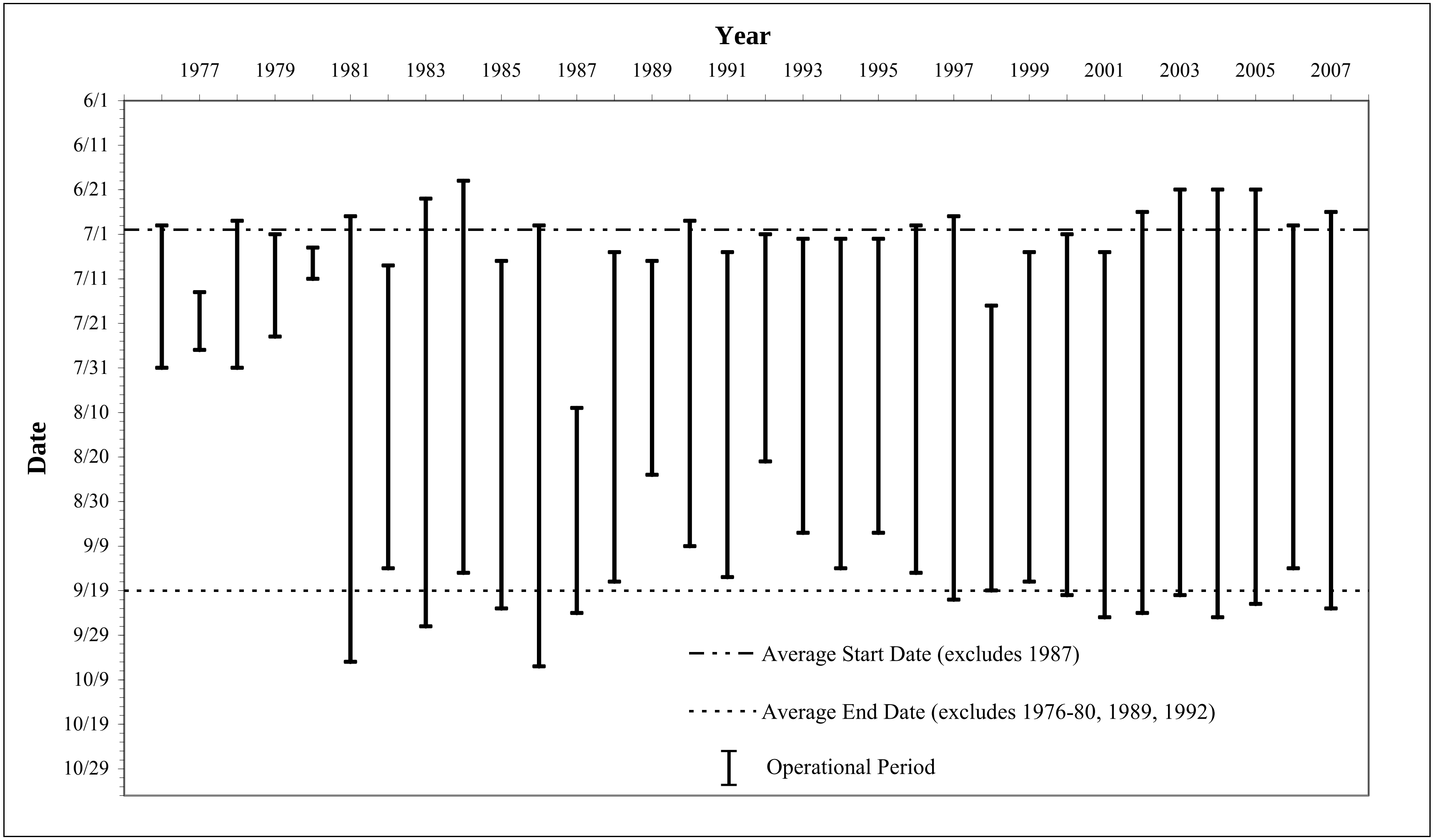
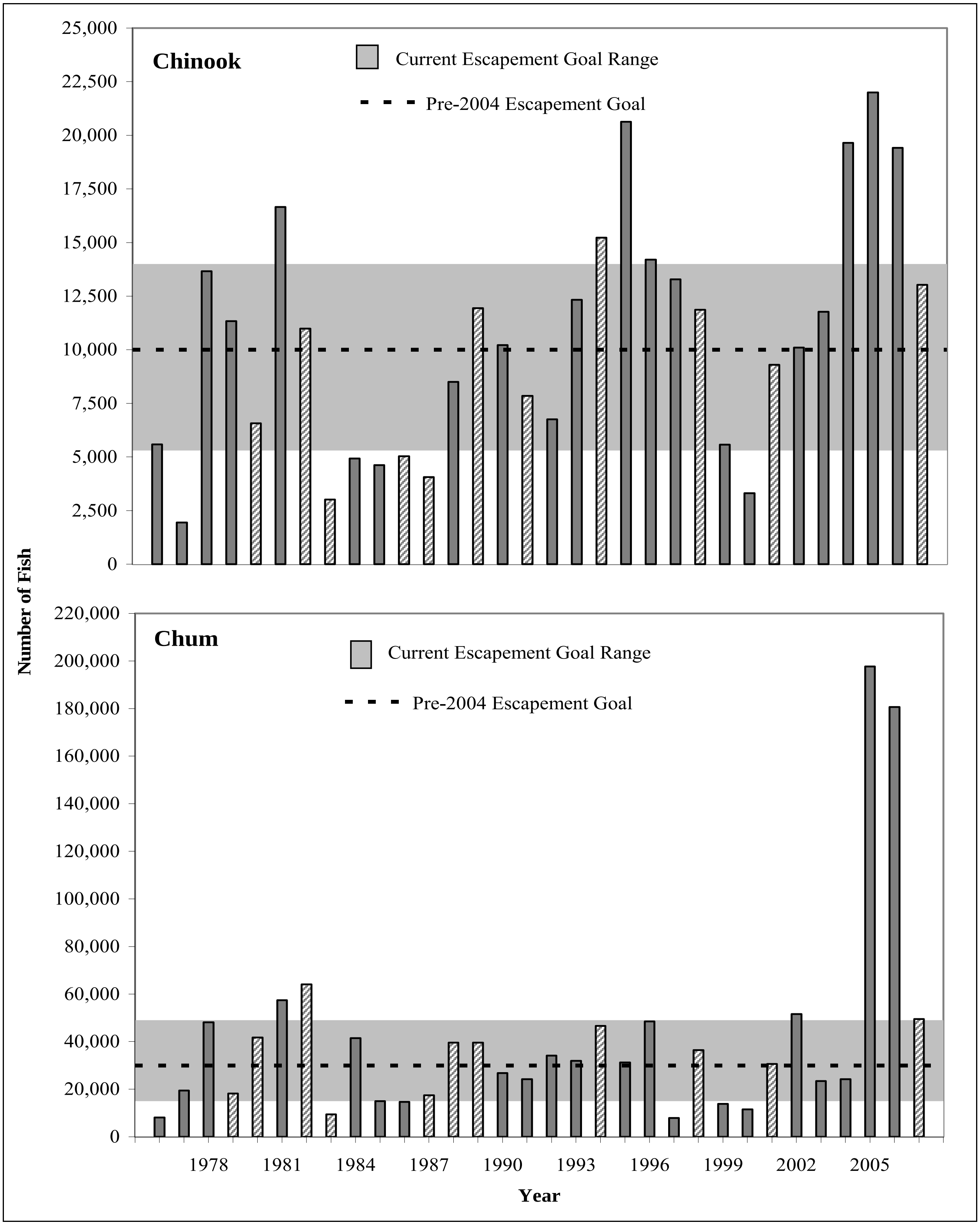
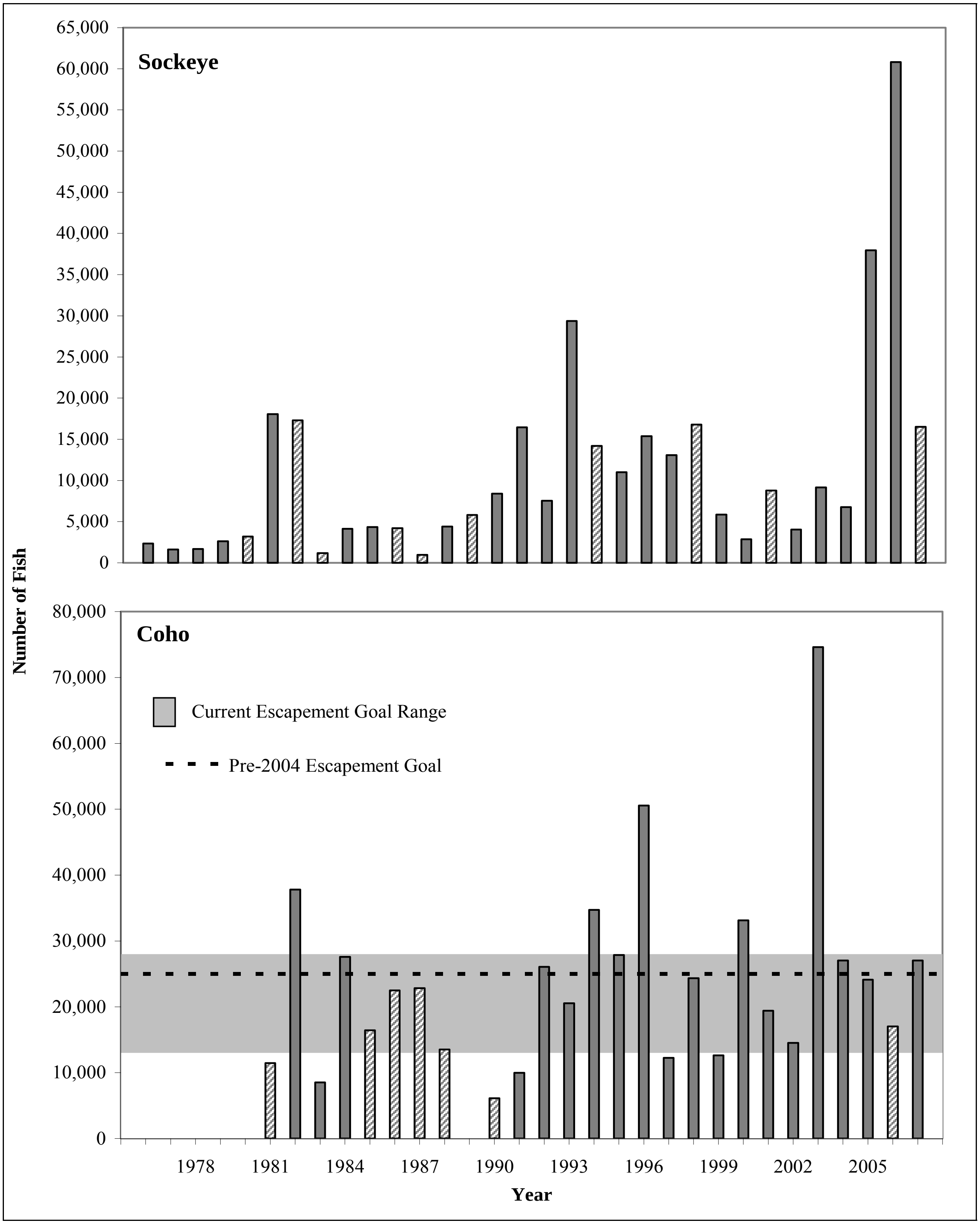


Figure 13.–Historical operational dates for the Kogrukluk River weir.



Note: Hatched bars represent years when more than 20% of the escapement was calculated through estimation methods.

Figure 14.–Historical Chinook and chum salmon escapement with the pre-2004 minimum escapement goal and the current escapement goal range at the Kogrukluk River weir.



Note: Hatched bars represent years when more than 20% of the escapement was calculated through estimation methods.

Figure 15.–Historical sockeye and coho salmon escapement with the pre-2004 minimum escapement goal and the current escapement goal range at the Kogrukluk River weir.

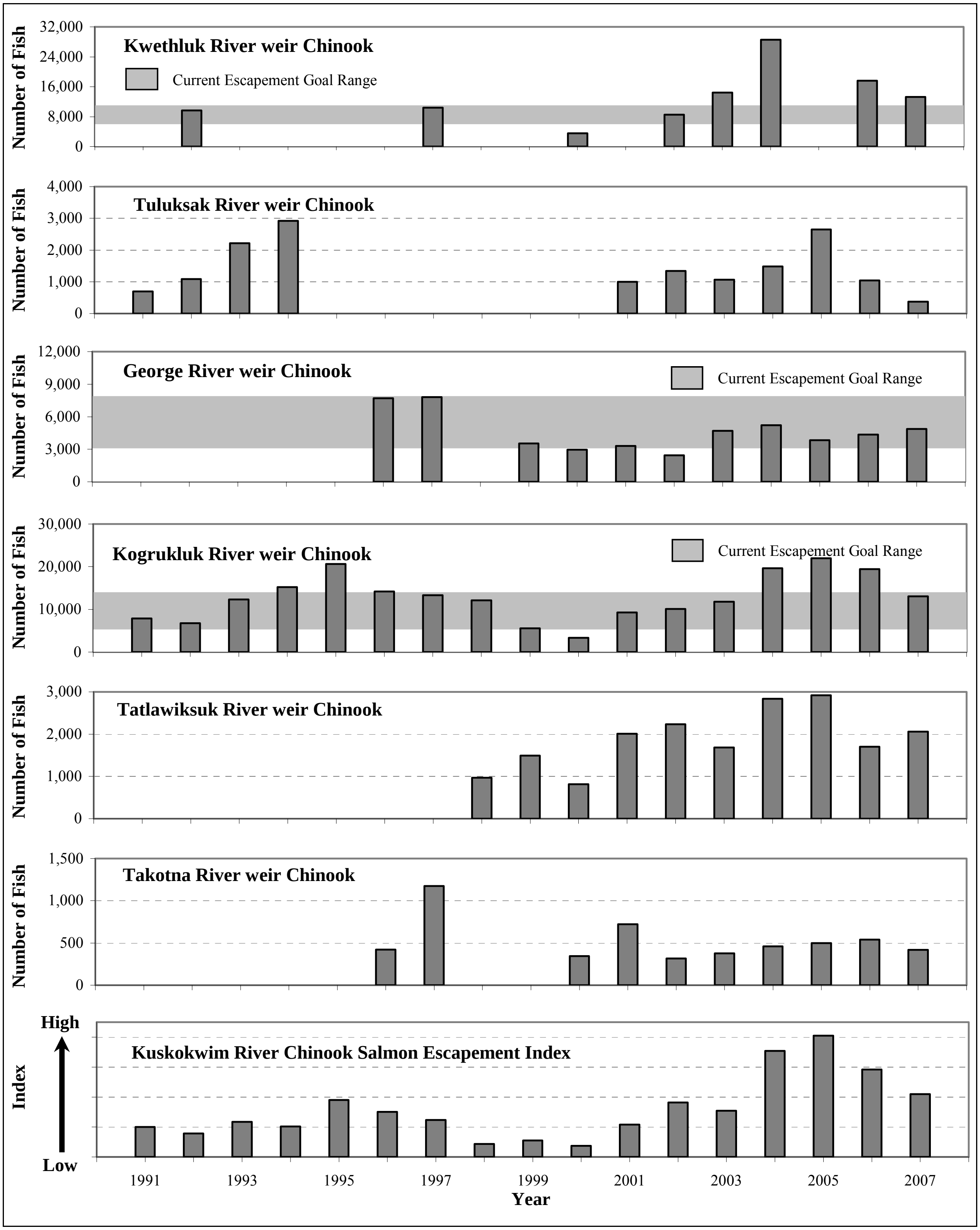
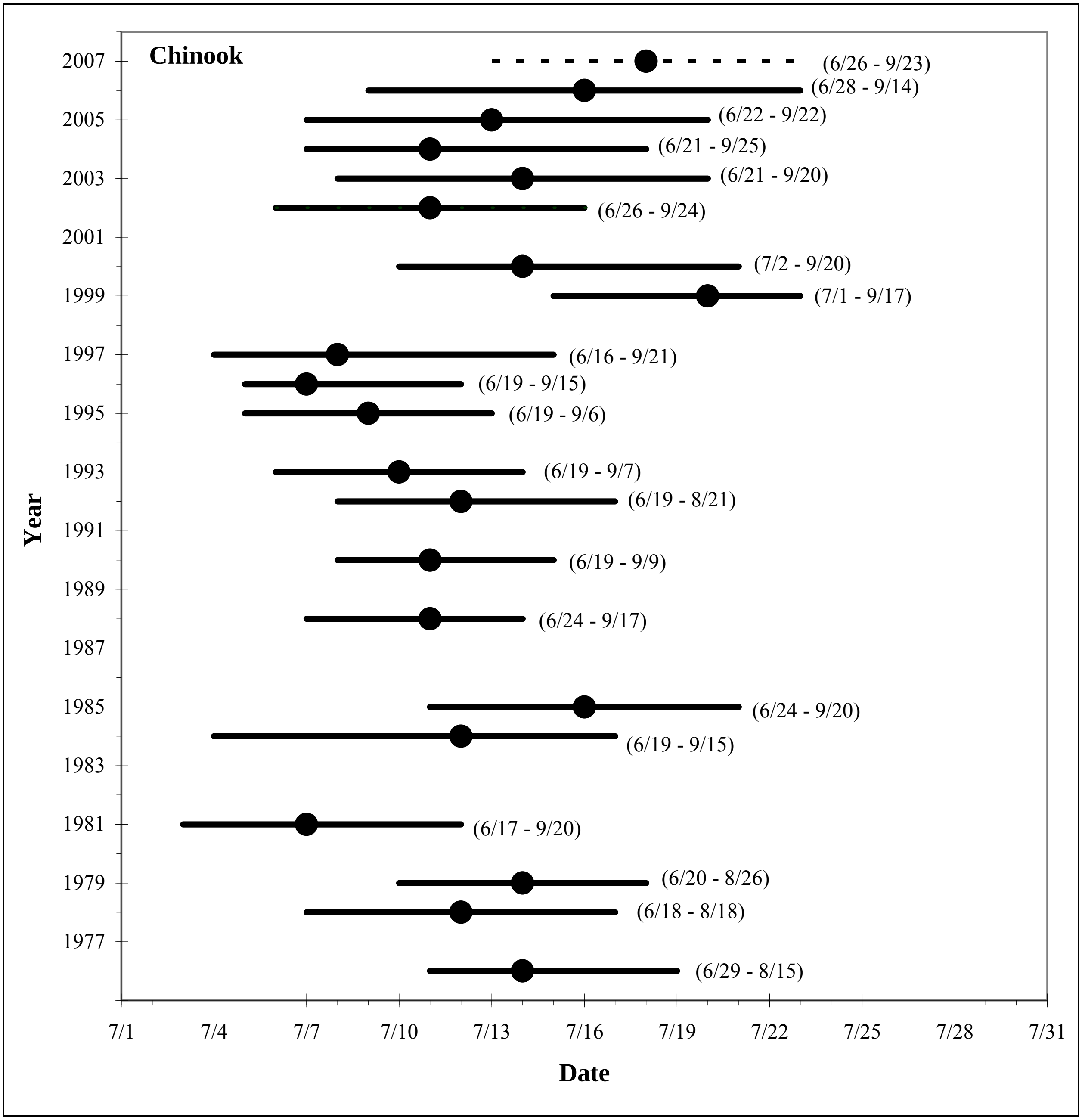


Figure 16.–Historical annual Chinook salmon escapement into 6 Kuskokwim River tributaries and annual Kuskokwim River Chinook salmon escapement indicies,1991–2007.



Note: Solid black lines represent dates when the central fifty percent of annual escapement passed in years with at least 80% observed passage. Circles represent the median passage dates. The 2007 annual escapement consists of only 53% observed passage but is included for comparison and denoted with a dashed line. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 17.–Historical annual run timing of Chinook salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2007.

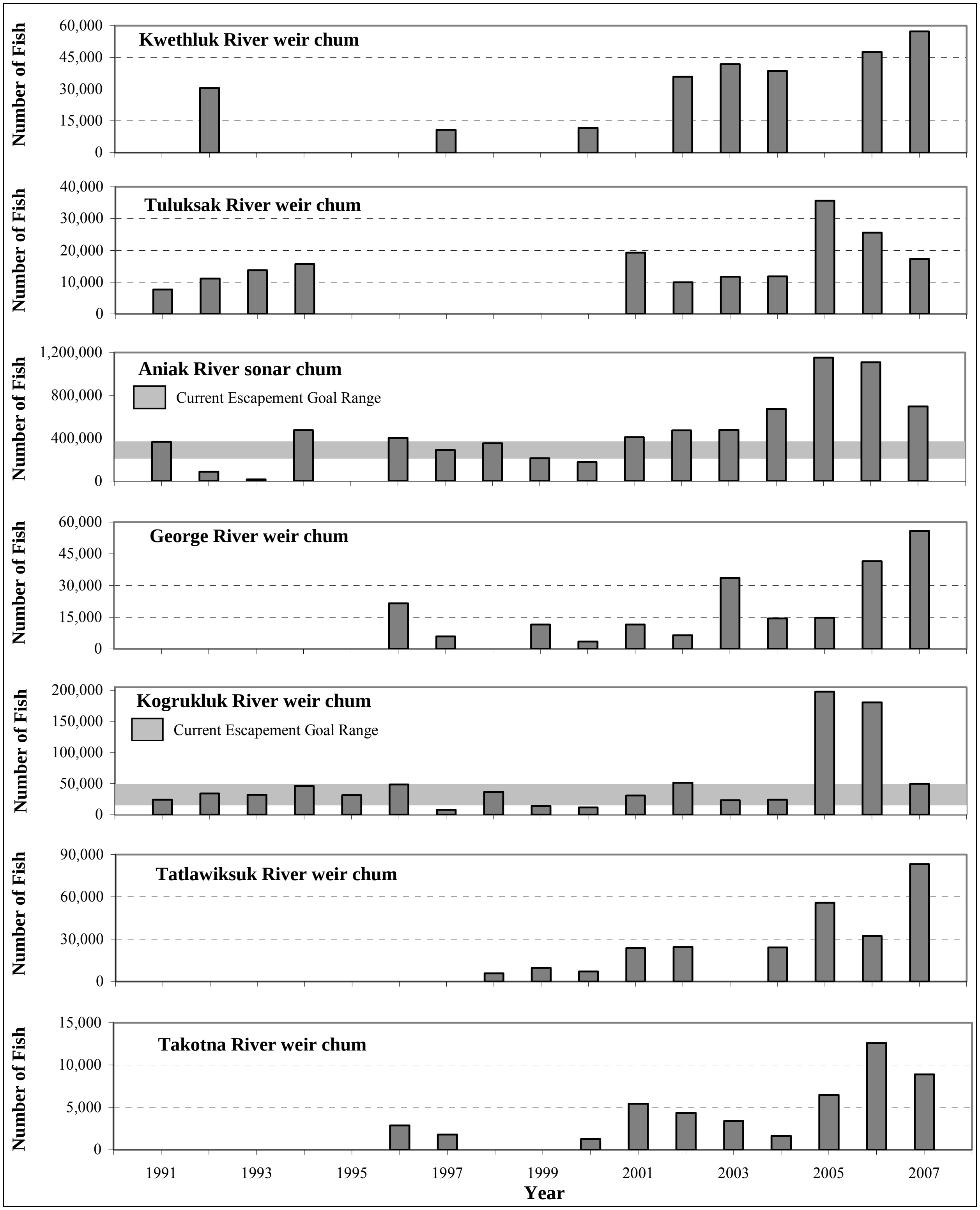
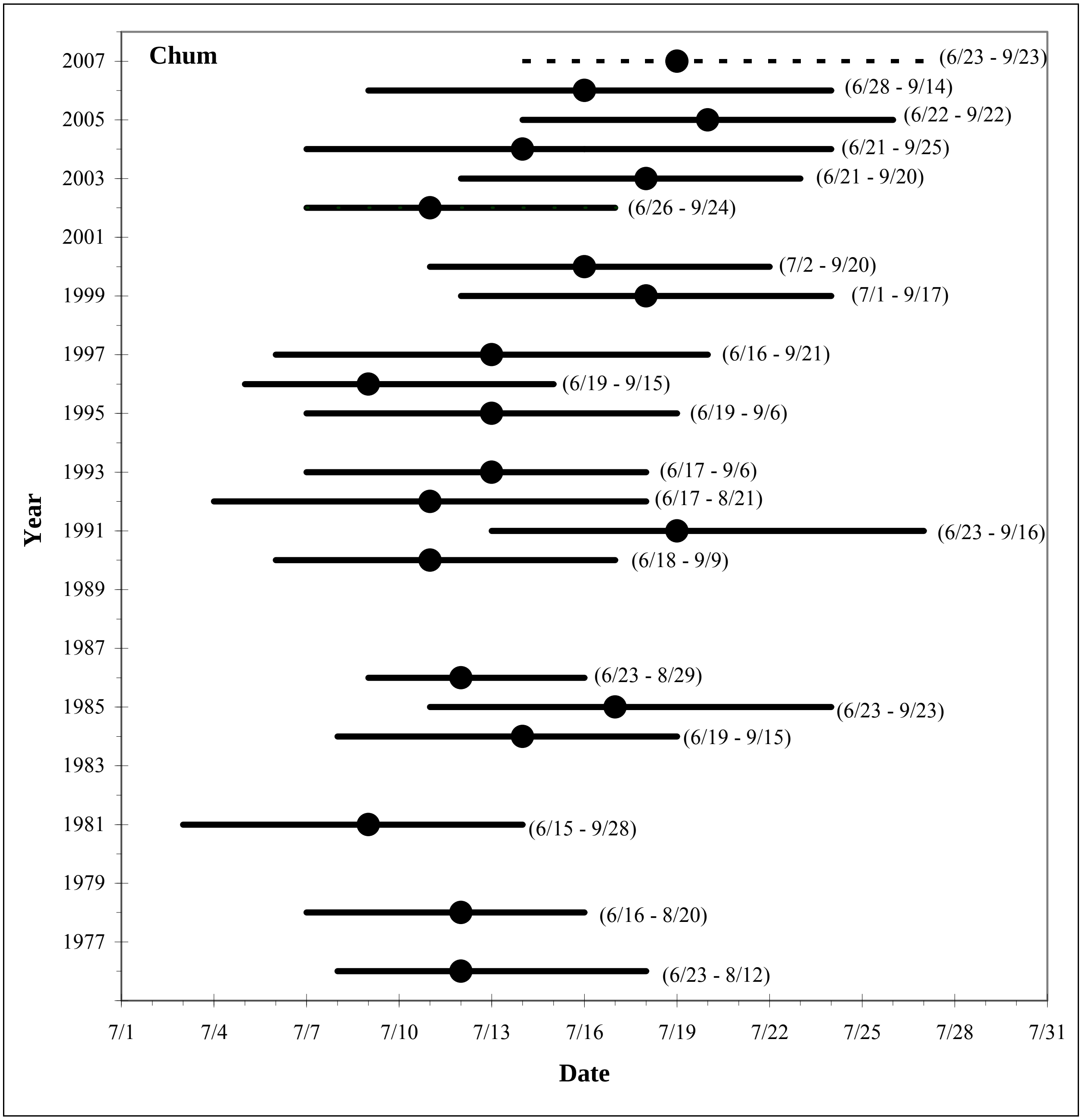


Figure 18.–Historical annual chum salmon escapement into 7 Kuskokwim River tributaries, 1991–2007.



Note: Solid black lines represent dates when the central fifty percent of annual escapement passed in years with at least 80% observed passage. Circles represent the median passage dates. The 2007 annual escapement consists of only 63% observed passage but is included for comparison and denoted with a dashed line. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 19.–Historical annual run timing of chum salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2007.

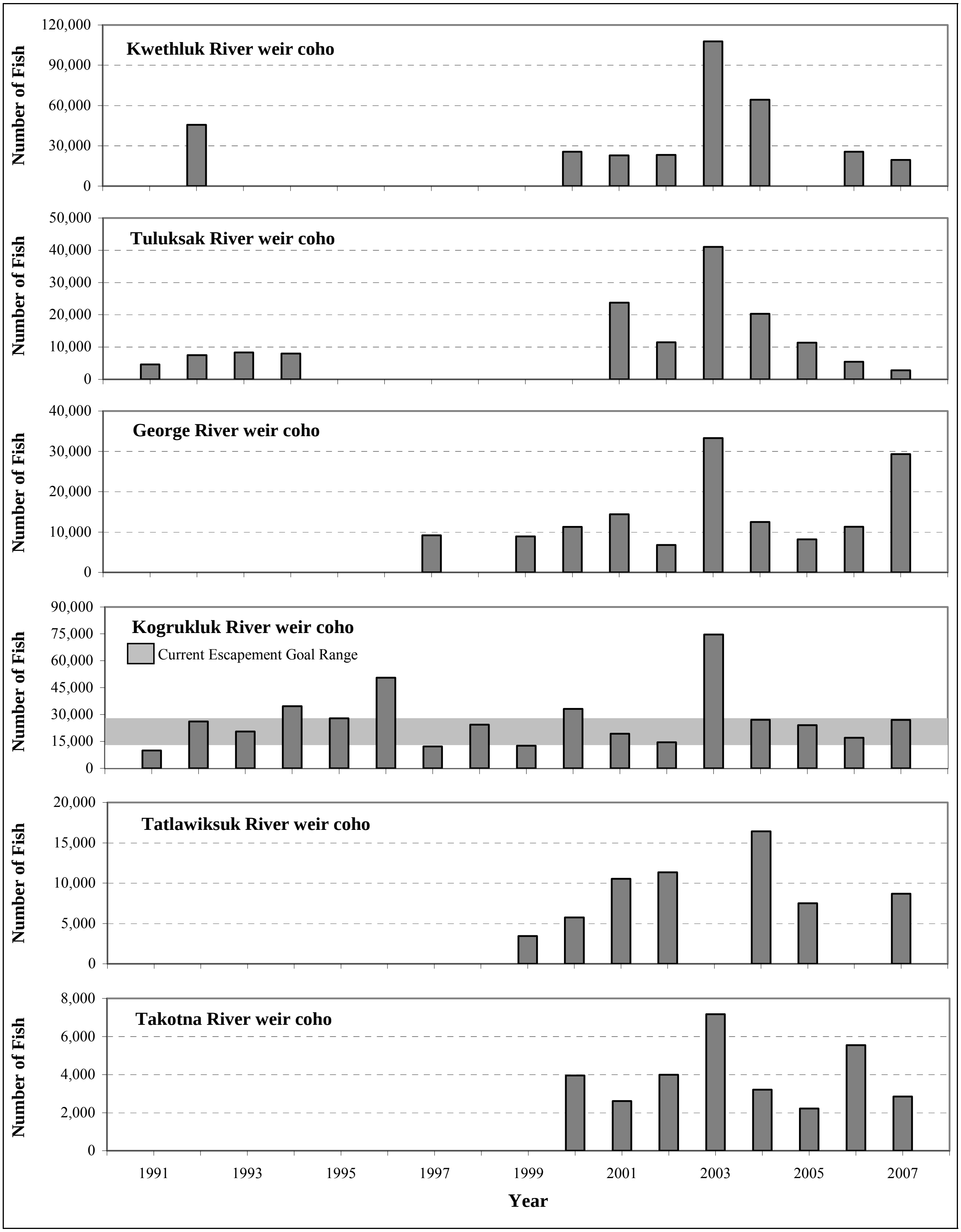
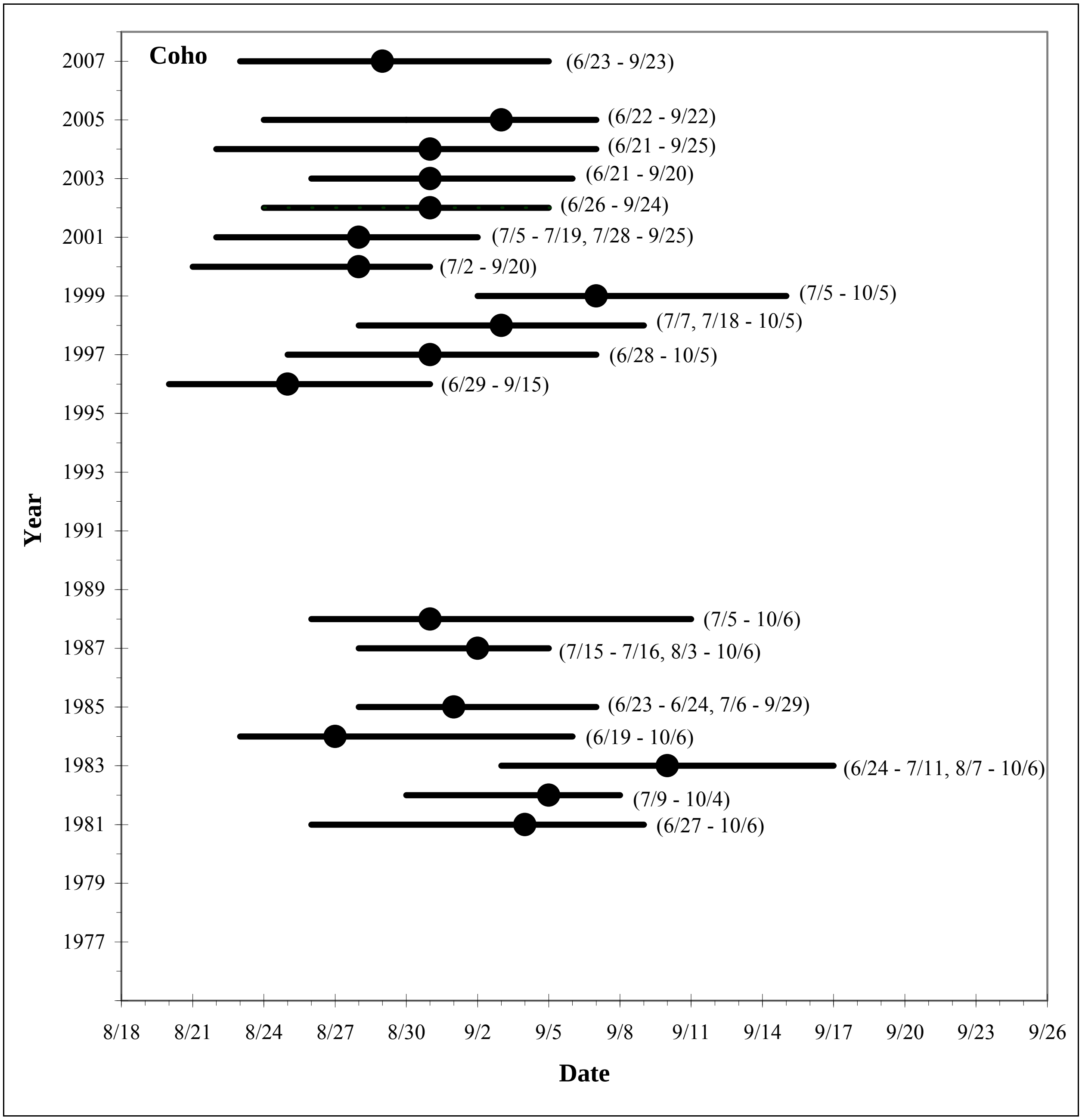
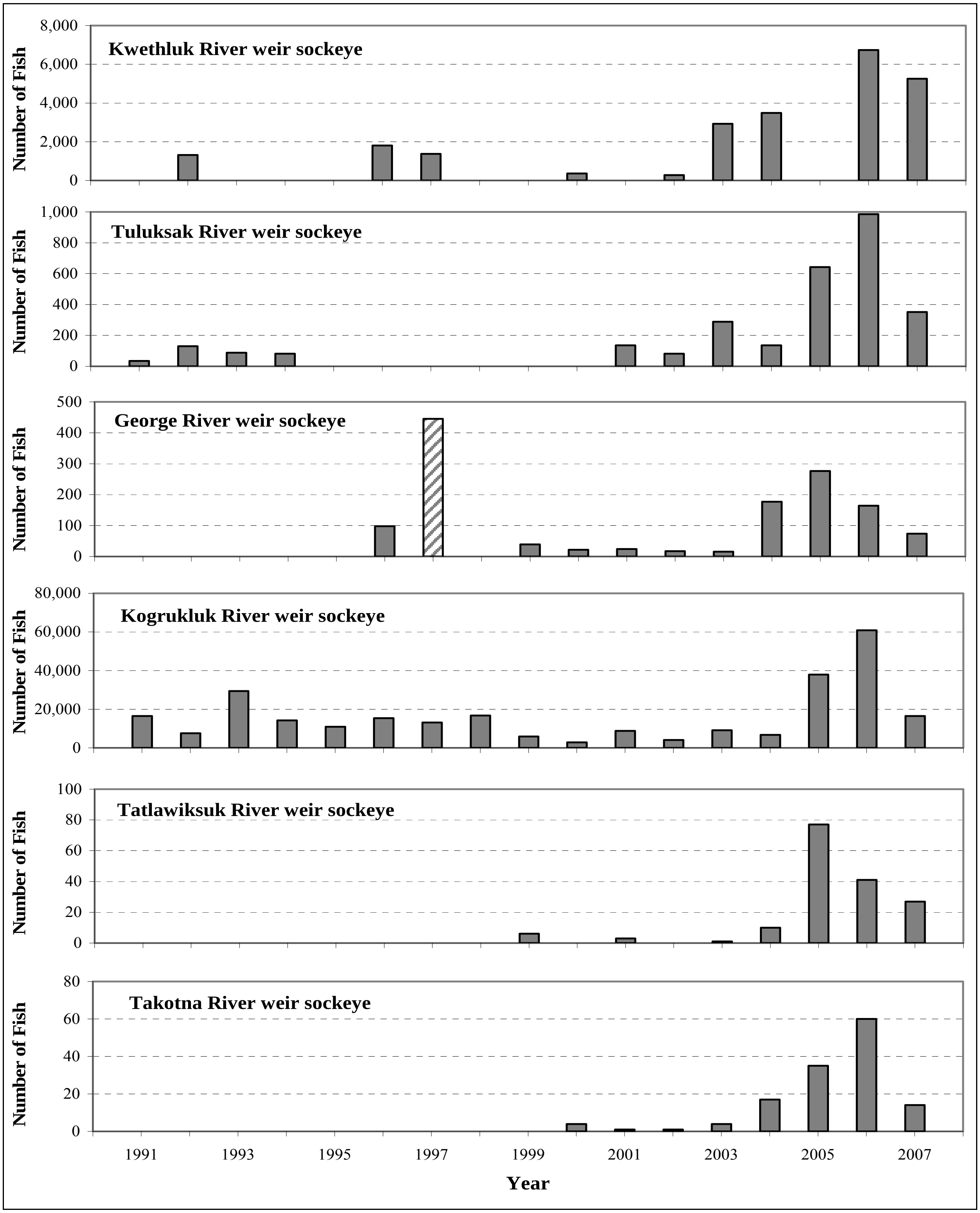


Figure 20.–Historical annual coho salmon escapement into 6 Kuskokwim Rive tributaries, 1991–2007.



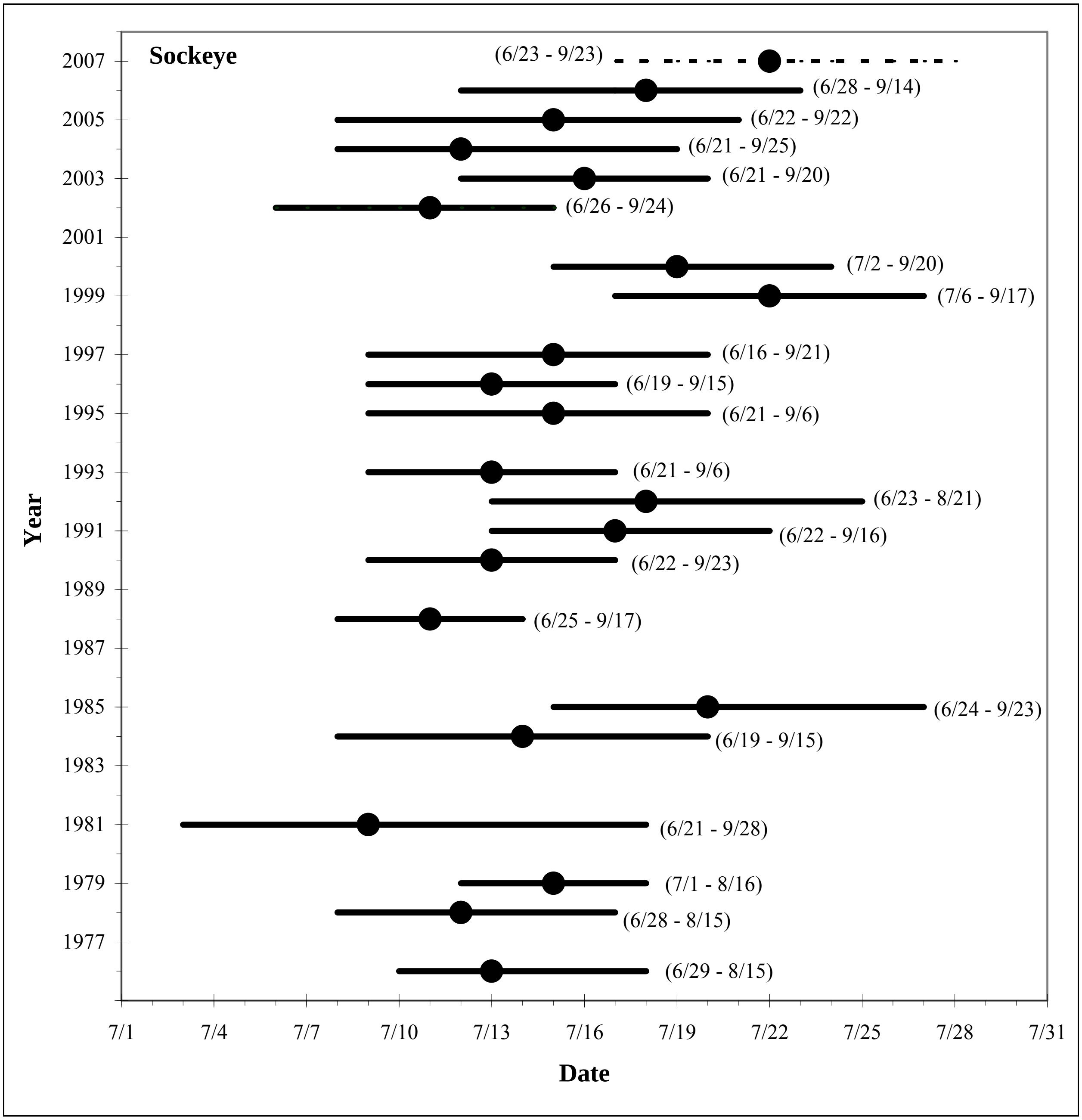
Note: Solid black lines represent dates when the central fifty percent of annual escapement passed in years with at least 80% observed passage. Circles represent the median passage dates. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 21.–Historical annual run timing of coho salmon base on cumulative percent passage at Kogrukluk River weir, 1976–2007.



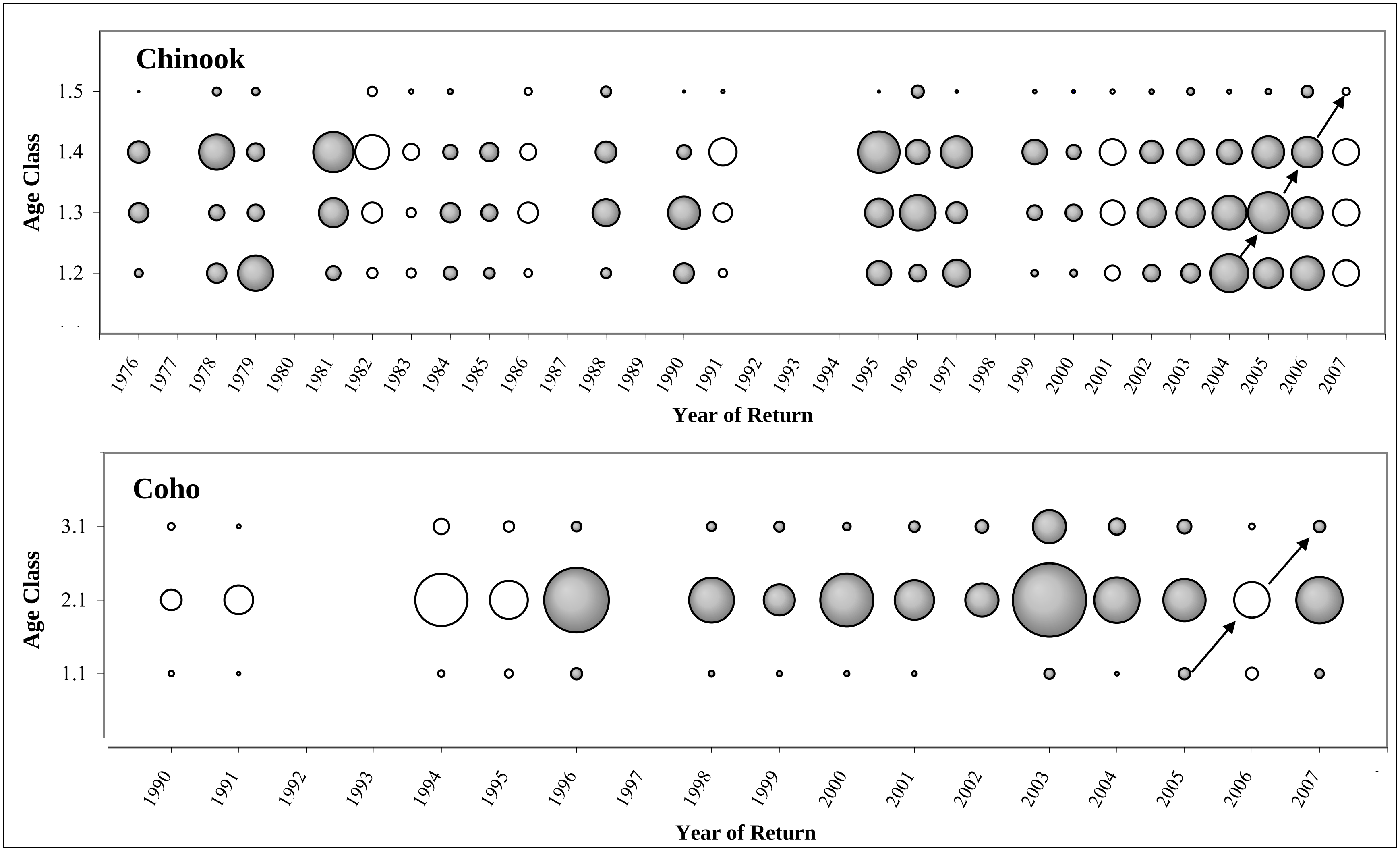
Note: Sockeye salmon escapement at the George River weir in 1997 may be incorrect; investigators suspect possible species mis-identification.

Figure 22.–Historical annual sockeye salmon escapement into 6 Kuskokwim River tributaries, 1991–2007.



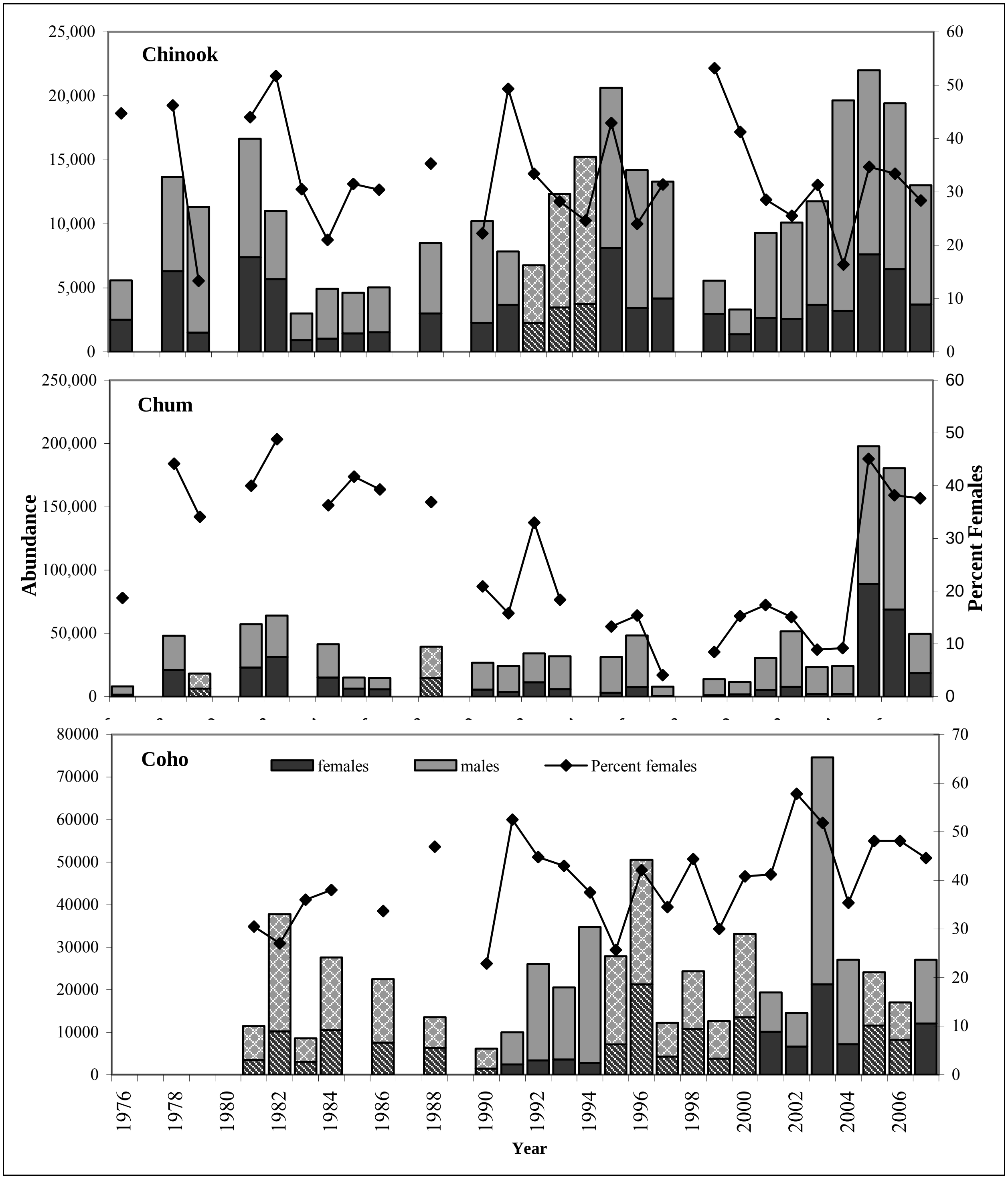
Note: Solid black lines represent dates when the central fifty percent of annual escapement passed in years with at least 80% observed passage. Circles represent the median passage dates. The 2007 annual escapement consists of only 60% observed passage but is included for comparison and denoted with a dashed line. As a means to gauge the certainty of the run timing estimates, date ranges with escapement information (observed passage plus passage estimates) are in parentheses beside each annual line.

Figure 23.–Historical annual run timing of sockeye salmon based on cumulative percent passage at Kogrukluk River weir, 1976–2007.



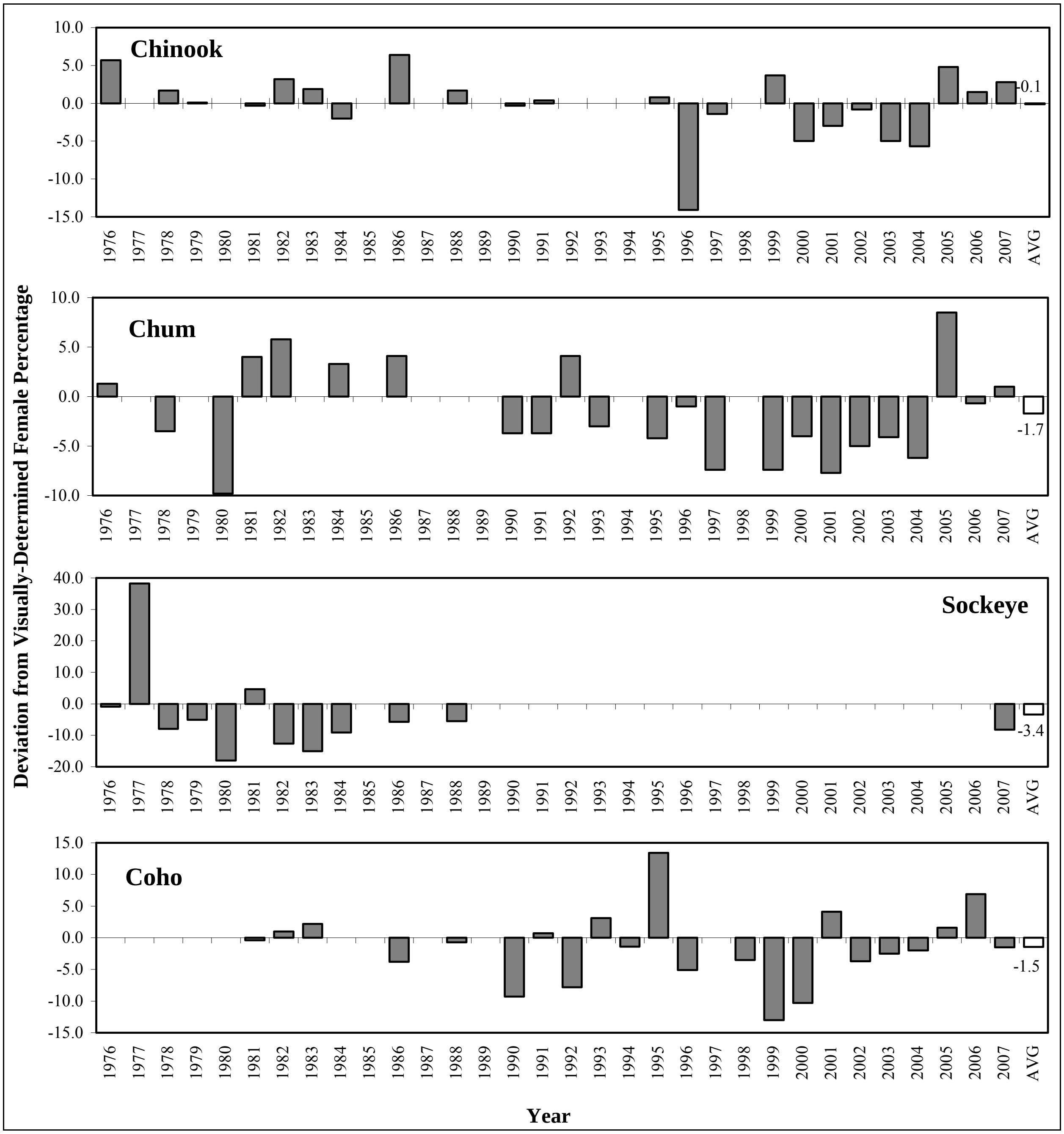
Note: Size of circles represents relative abundance and arrows illustrate a cohort group. Plots that appear empty (white) correspond to years when greater than 20% of reported escapement was derived from daily passage estimates. Years when sample objectives were not achieved contain no data plots.

Figure 24.–Relative age-class abundance of Chinook (1976–2007) and coho salmon (1990–2007) by return year at the Kogrukluk River weir.



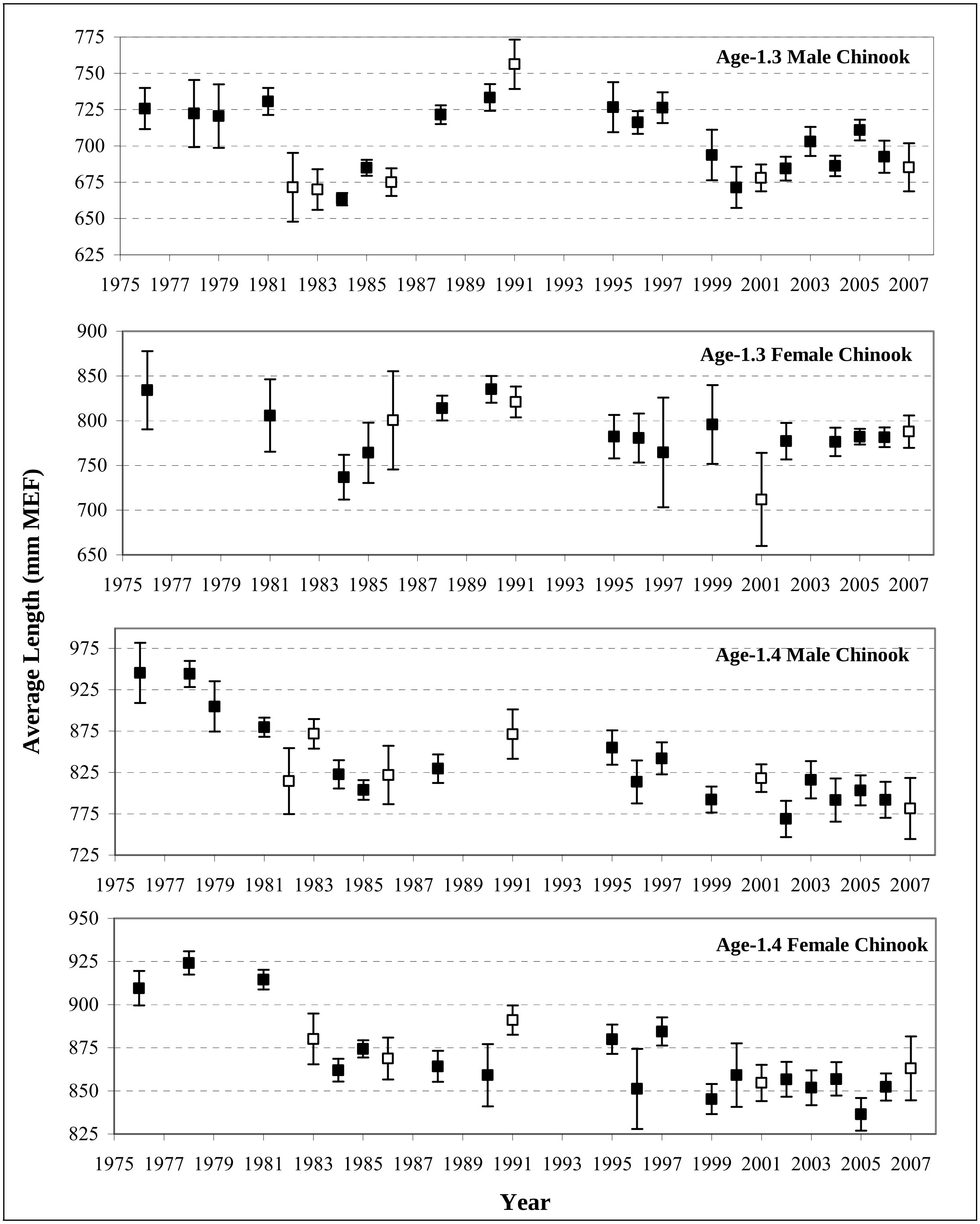
Note: Hatched bars represent years in which female salmon composition was determined from non ASL data due to insufficient ASL data. Lines represent the annual proportion of female salmon.

Figure 25.–Historical Chinook, chum, and coho salmon escapement by sex relative to percent composition of female salmon.



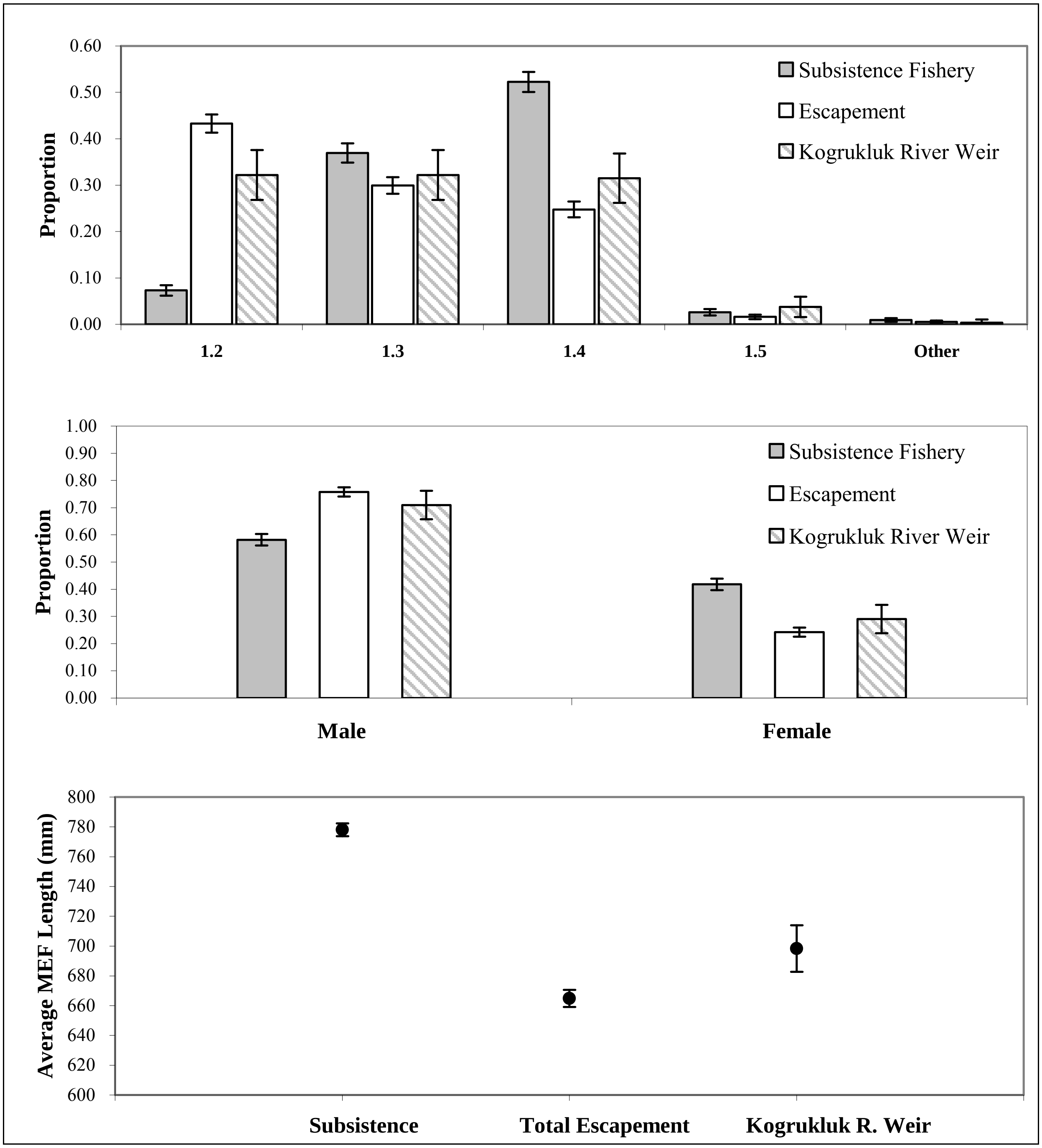
Note: The horizontal line bisecting the plot area at y=0 represent the visually-determined female percentage during a given year. Columns dropping below this line are instances when the female percentage derived from ASL sampling were less than that of the visual method; columns rising above this line are instances when the female percentage derived from ASL sampling was more than that of the visual method.

Figure 26.–Annual deviation of percent females as determined by ASL sampling methods from the percentage determined through standard escapement counts.



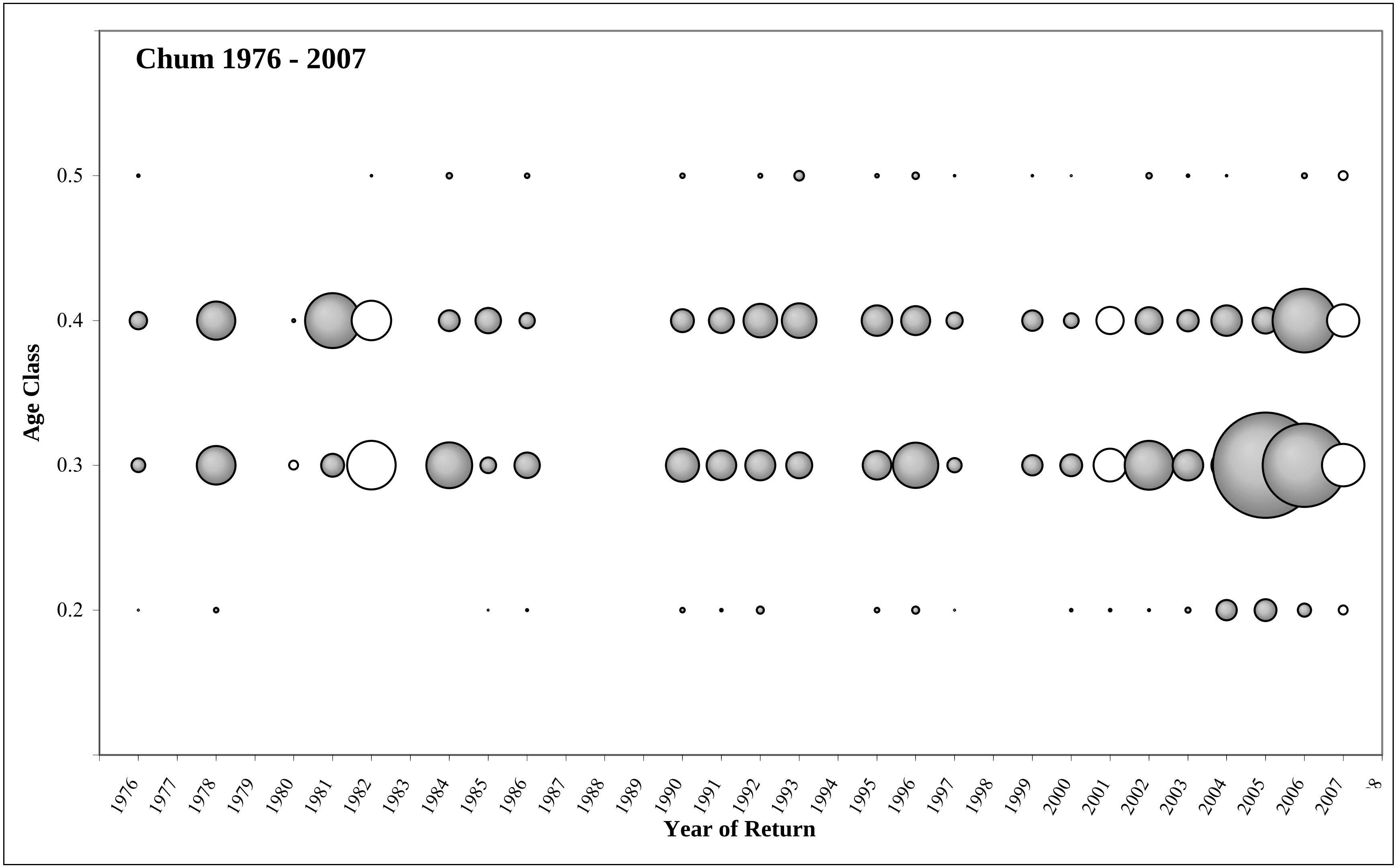
Note: Years when sampling effort was not well distributed throughout the run were omitted. Years for which annual escapement consisted of greater than 20% estimated passage are delineated with white squares.

Figure 27.–Historical average annual length for Chinook salmon with 95% confidence intervals at Kogrukluk River weir.



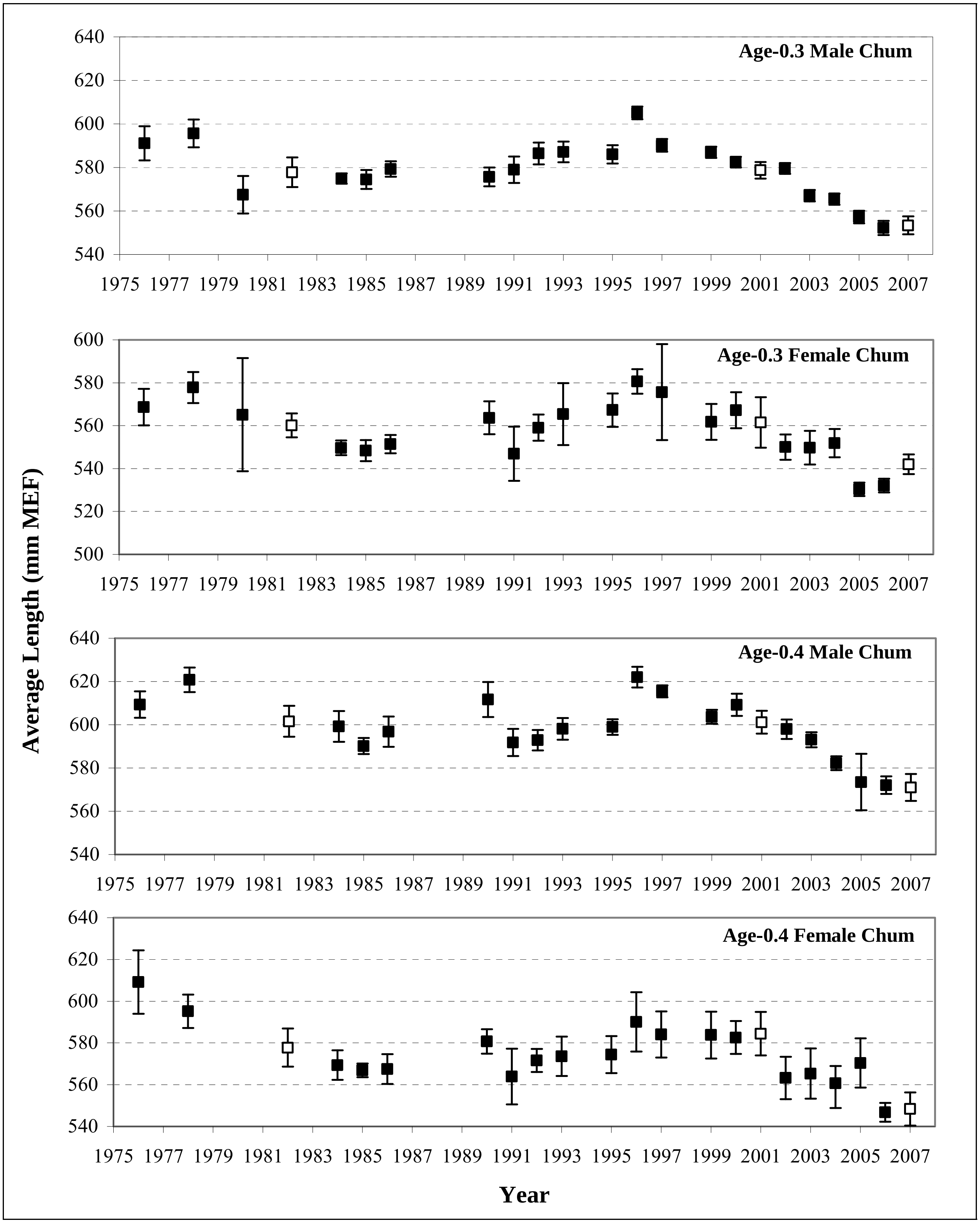
Note: Few Chinook salmon were harvested in the coho salmon-directed commercial fishery in 2007; Chinook salmon samples were not collected.

Figure 28.–ASL composition of the 2007 Kuskokwim River Chinook salmon commercial and subsistence harvests, total monitored escapement, and Kogrukluk River weir (+/- 95% confidence interval).



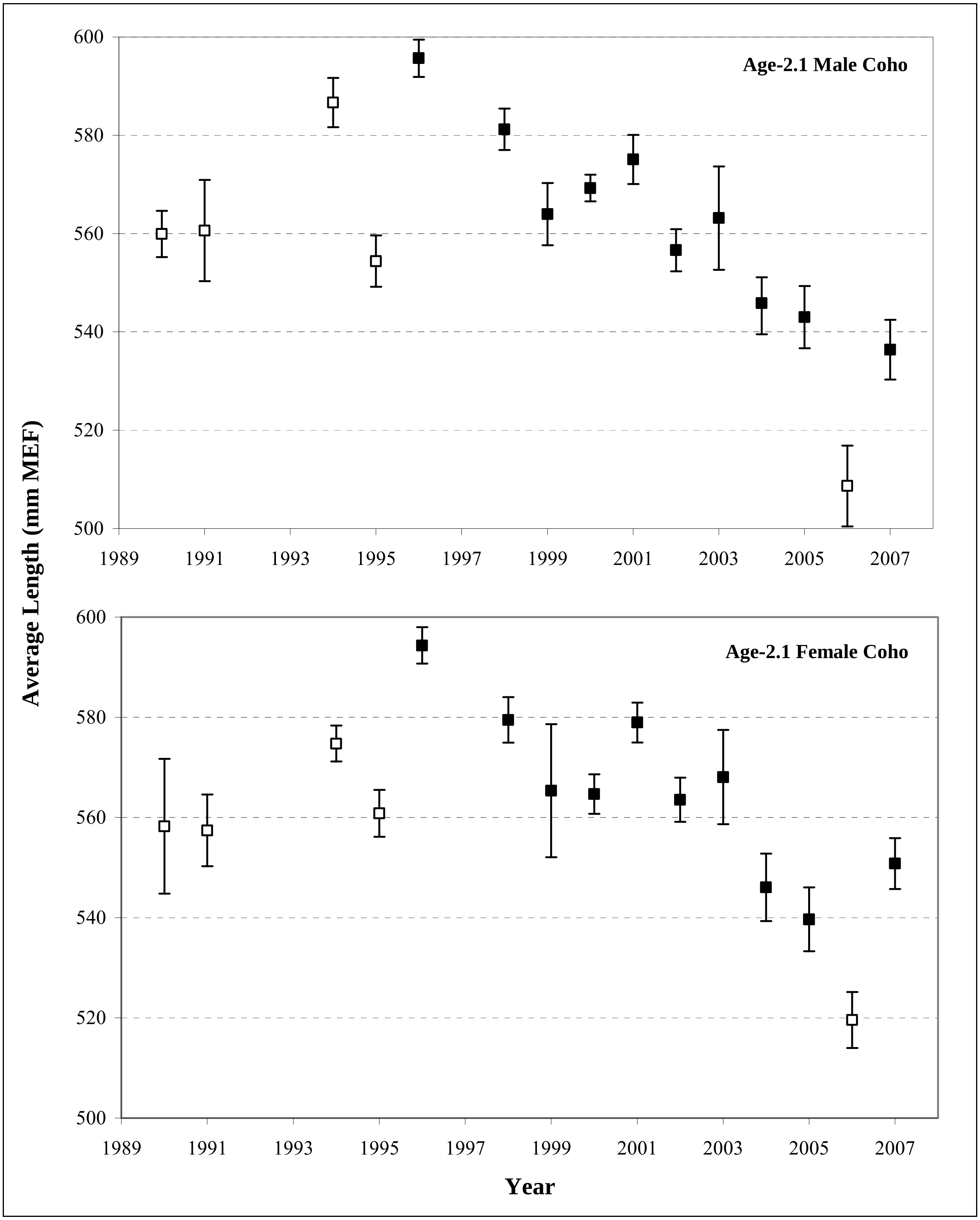
Note: Size of circles represents relative abundance. Plots that appear empty (white) correspond to years when greater than 20% of reported escapement was derived from daily passage estimates. Years when sample objectives were not achieved contain no data plots.

Figure 29.–Relative age-class abundance of chum salmon by return year at Kogrukluk River weir.



Note: Years when sampling effort was not well-distributed throughout the run were omitted. Years for which annual escapement consisted of greater than 20% estimated passage are delineated with white squares.

Figure 30.–Historical average annual length for chum salmon with 95% confidence intervals at the Kogrukluk River weir.



Note: Years when sampling effort was not well-distributed throughout the run were omitted. Years for which annual escapement consisted of greater than 20% estimated passage are delineated with white squares.

Figure 31.–Historical average annual length for coho salmon with 95% confidence intervals at Kogrukluk River weir.

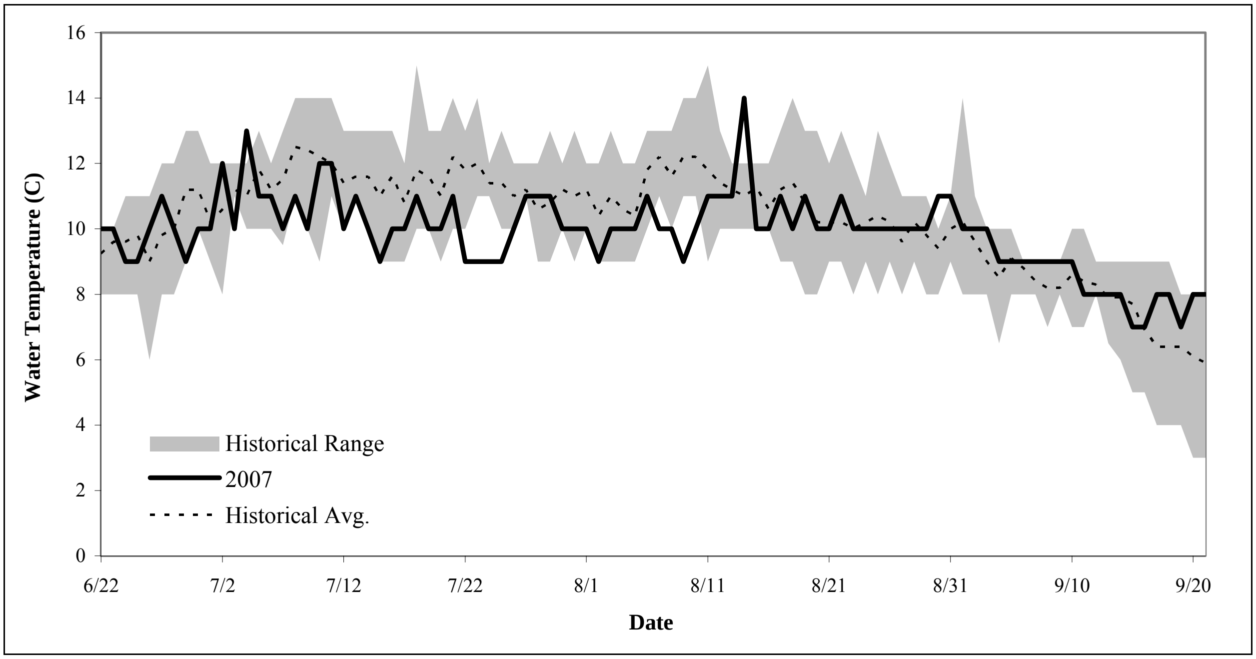


Figure 32.–Daily morning water temperature at Kogrukluk River weir in 2007 relative to historical average, minimum, and maximum morning readings from 2002–2006.

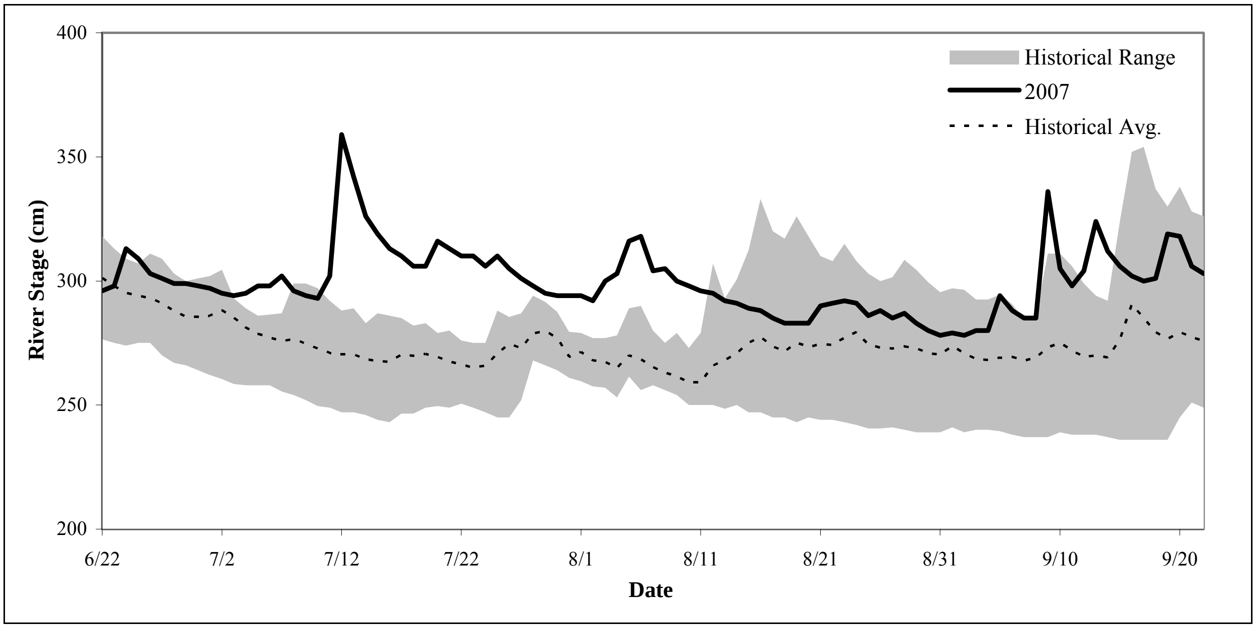
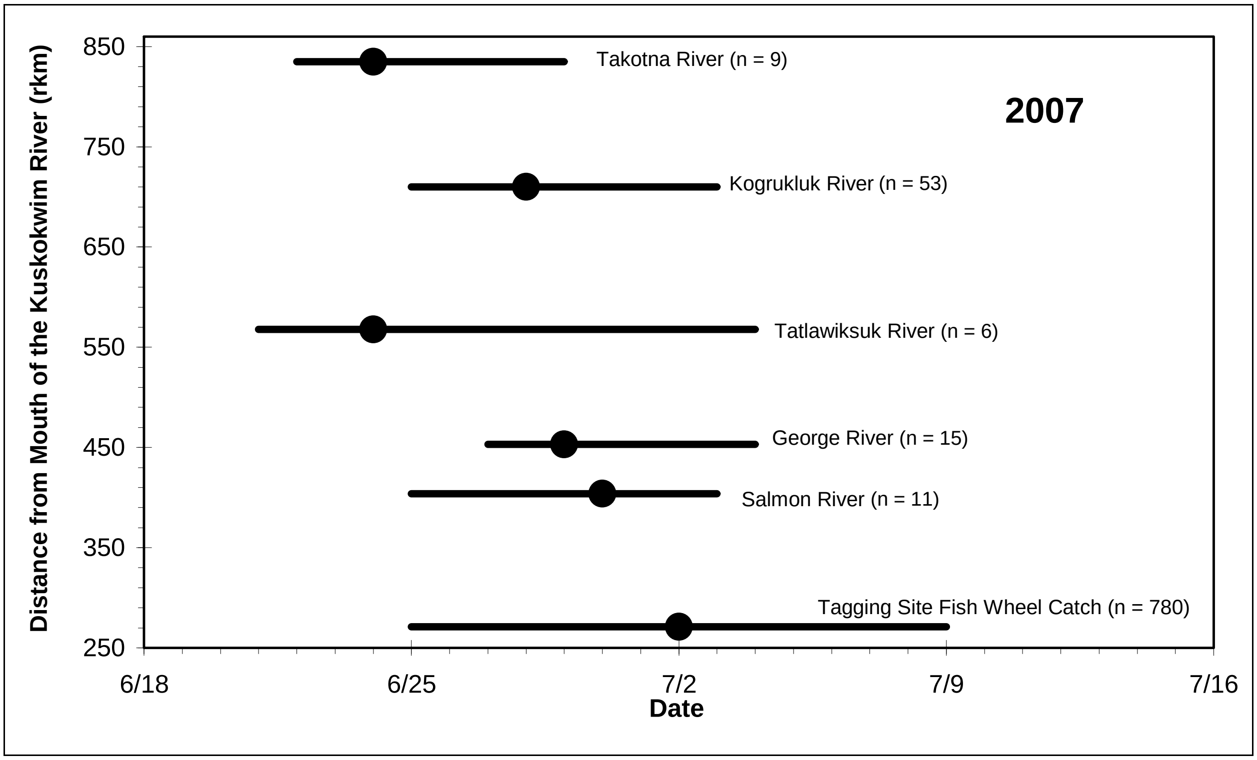
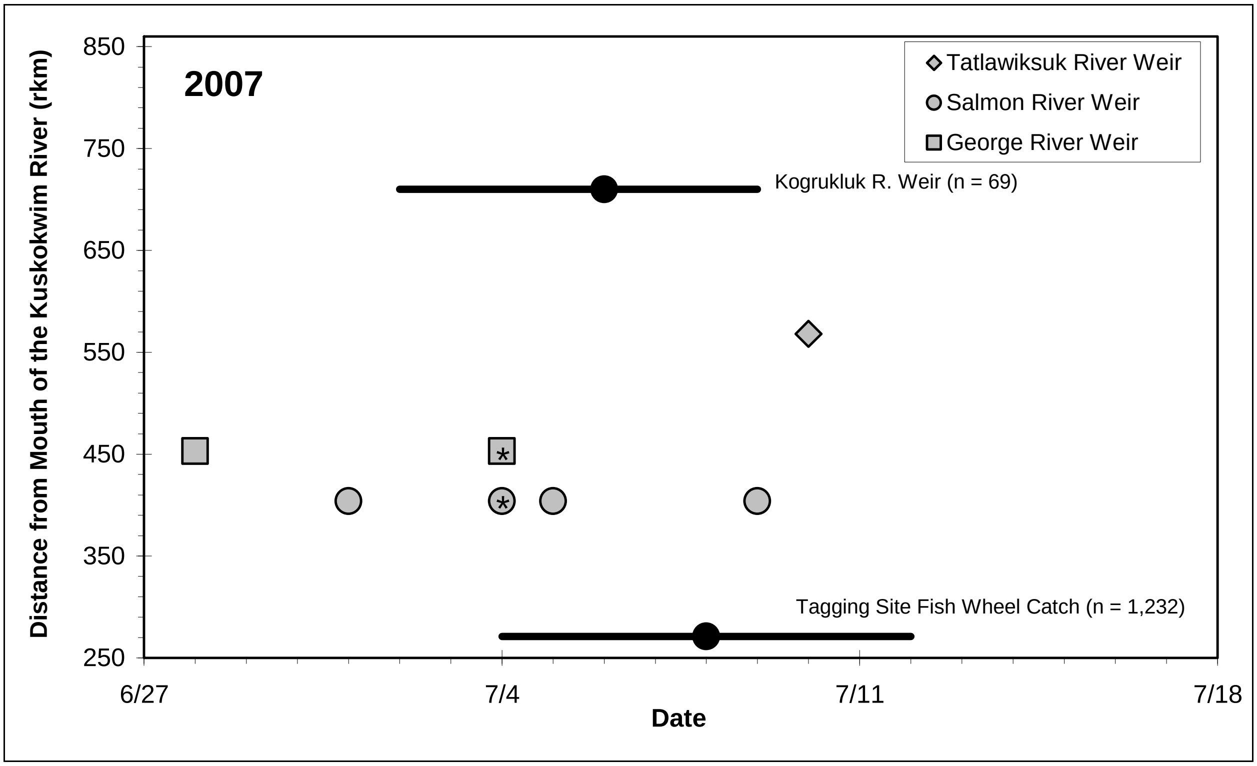


Figure 33.–Daily morning river stage at Kogrukluk River weir in 2007 relative to historical average, minimum, and maximum morning readings from 2002–2006.



Note: Horizontal lines represent the central 50% and circles represent the median passage date. Results are confounded by inconsistent operational dates resulting from high water levels, which affected tag recovery.

Figure 34.–Dates when individual Chinook salmon stocks passed through the Kalskag tagging sites (rkm 271) based on anchor- and radio-tagging studies.



Note: Horizontal lines represent the central 50% and circles represent the median passage date. Results are confounded by inconsistent operational dates resulting from high water levels, which affected tag recovery. Points that contain an asterisk represent 2 fish.

Figure 35.–Dates when individual sockeye salmon stocks passed through the Kalskag tagging sites (rkm 271) based on anchor- and radio-tagging studies.

APPENDIX A. DAILY SALMON PASSAGE AT THE KOGRUKLUK RIVER WEIR, 2007

Appendix A1.–Daily passage counts by species at Kogrukluk River weir, 2007.

	Chinook Salmon		Sockeye Salmon		Chum Salmon		Pink	Coho Salmon		Dolly	White-	
Date	Male	Female	Male	Female	Male	Female	Salmon	Male	Female	Varden[a]	fish	Other[b]
6/26[c]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]
6/27	0	1	0	0	15	7	0	0	0	12	0	2G
6/28	0	1	0	0	10	5	0	0	0	6	0	1G
6/29	0	0	1	0	21	14	0	0	0	4	0	1G
6/30	1	0	0	0	28	16	0	0	0	1	0	0
7/1	8	6	1	0	57	47	0	0	0	5	0	0
7/2	9	1	0	0	114	61	0	0	0	10	0	0
7/3	10	6	4	4	127	74	0	0	0	9	0	0
7/4	87	30	4	11	291	162	0	0	0	11	0	2G
7/5	20	8	7	7	198	122	0	0	0	8	0	5G
7/6	28	7	2	4	279	143	0	0	0	4	0	0
7/7	59	12	10	21	464	290	0	0	0	4	0	0
7/8	295	67	21	64	555	340	0	0	0	5	0	0
7/9	598	81	47	104	803	505	0	0	0	4	0	0
7/10	407	57	47	150	1,094	627	0	0	0	7	0	0
7/11[c]	165[d]	25[d]	14[d]	52[d]	622[d]	279[d]	0[d]	0[d]	0[d]	4[d]	0[d]	0[d]
7/12[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/13[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/14[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/15[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/16[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/17[c]	53[d]	19[d]	21[d]	45[d]	426[d]	231[d]	1[d]	0[d]	0[d]	0[d]	0[d]	0[d]
7/18	584	141	442	610	1,844	1,077	4	0	0	1	0	0
7/19	600	154	420	436	1,648	844	1	0	0	0	0	0
7/20[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/21[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/22[c]	132[d]	33[d]	28[d]	41[d]	576[d]	306[d]	2[d]	0[d]	0[d]	0[d]	0[d]	0[d]
7/23	274	105	235	188	1,232	608	5	0	0	1	0	0
7/24	202	98	279	239	628	292	3	1	1	0	0	0
7/25	207	134	430	307	491	221	3	0	0	0	0	0
7/26	313	170	608	466	1,214	537	4	5	2	0	0	0
7/27	216	134	427	322	1,084	546	3	4	1	2	0	0
7/28	152	98	365	267	1,053	566	1	2	4	1	0	0

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Appendix A1.–Page 2 of 3.

Date	Chinook Salmon Male	Chinook Salmon Female	Sockeye Salmon Male	Sockeye Salmon Female	Chum Salmon Male	Chum Salmon Female	Pink Salmon	Coho Salmon Male	Coho Salmon Female	Dolly Varden[a]	White-fish	Other[b]
7/29	210	147	516	346	1,128	575	2	3	4	0	0	0
7/30	103	36	355	264	1,053	639	3	6	11	0	0	0
7/31	29	24	173	113	284	123	0	4	2	0	0	0
8/1	33	21	182	131	147	39	0	8	7	0	0	0
8/2	49	47	165	98	134	86	0	12	11	0	0	0
8/3	90	52	104	90	291	146	0	24	16	2	0	0
8/4[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/5[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/6[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/7[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8/8	34	20	52	35	343	339	0	55	24	24	1	0
8/9	25	9	46	40	213	231	0	71	47	15	0	0
8/10	22	7	45	51	222	202	0	48	43	26	0	0
8/11	15	2	32	42	154	158	0	29	22	43	0	0
8/12	24	4	38	47	227	218	0	173	114	51	1	0
8/13	19	4	35	43	161	150	0	251	171	112	1	0
8/14	14	4	19	17	103	101	0	202	135	124	0	0
8/15	4	1	17	17	78	109	0	84	69	226	0	0
8/16	6	1	8	15	77	80	0	196	137	117	1	1P
8/17	9	1	4	17	66	72	0	198	131	138	1	0
8/18	5	1	4	7	35	48	0	166	104	61	2	0
8/19	4	0	4	12	58	40	0	215	146	159	0	0
8/20	4	0	3	11	38	41	0	439	276	196	0	0
8/21	6	1	1	9	44	31	0	324	229	181	1	0
8/22	5	0	2	6	43	29	0	712	440	310	1	0
8/23	5	0	4	4	31	20	0	856	612	355	0	0
8/24	5	0	0	4	21	23	0	626	511	187	0	0
8/25	3	0	3	3	14	17	0	1,000	698	159	0	0
8/26	4	0	1	1	10	13	0	454	345	134	0	0
8/27	1	0	1	1	8	8	0	463	348	113	5	0
8/28	1	0	0	0	12	4	0	735	558	153	6	0
8/29	0	0	1	0	6	6	0	822	668	69	4	0
8/30	1	0	1	2	6	5	0	375	397	77	2	0

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Appendix A1.–Page 3 of 3.

Date	Chinook Salmon Male	Chinook Salmon Female	Sockeye Salmon Male	Sockeye Salmon Female	Chum Salmon Male	Chum Salmon Female	Pink Salmon	Coho Salmon Male	Coho Salmon Female	Dolly Varden[a]	White-fish	Other[b]
8/31	1	0	1	0	4	1	0	473	437	49	1	0
9/1	0	0	0	2	6	6	0	634	551	64	1	0
9/2	0	0	0	0	7	0	0	508	501	64	4	0
9/3	1	0	1	0	6	2	0	430	408	49	0	0
9/4	0	0	0	0	2	1	0	420	511	113	12	0
9/5	0	0	1	1	2	2	0	553	600	69	9	0
9/6	1	0	1	0	5	1	0	277	283	30	7	0
9/7	0	0	0	1	1	1	0	227	336	21	4	0
9/8	0	0	0	0	0	2	0	275	392	48	11	0
9/9[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/10[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/11[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/12[c]	0[d]	0[d]	0[d]	0[d]	1[d]	0[d]	0[d]	127[d]	138[d]	0[d]	1[d]	0[d]
9/13[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/14[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/15[c]	0[d]	0[d]	0[d]	0[d]	1[d]	0[d]	0[d]	19[d]	18[d]	0[d]	0[d]	0[d]
9/16	0	0	2	1	1	0	0	86	123	1	5	0
9/17	0	0	0	0	2	4	0	66	128	4	2	0
9/18	0	0	0	0	2	0	0	66	97	0	0	0
9/19[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/20[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9/21[c]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	0[d]	9[d]	18[d]	1[d]	0[d]	0[d]
9/22	0	0	0	0	1	3	0	42	76	2	6	0
9/23	0	0	0	0	1	2	0	51	69	3	5	0

[a] Counts represent sexually mature fish only.

[b] G= Arctic grayling; P= Northern pike: Counts may not correspond to actual day observed.

[c] Weir was inoperable for all or part of the day.

[d] Incomplete or partial daily count.

APPENDIX B. DAILY CARCASS COUNTS AT THE KOGRUKLUK RIVER WEIR, 2007

Appendix B1.–Daily carcass counts at the Kogrukluk River weir, 2007.

Date	Chinook Salmon	Sockeye Salmon	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden	White-fish	Other[a]	
6/26[b]	0	0	0	0	0	0	0	0	
6/27	0	0	0	0	0	0	1	0	
6/28	0	0	0	0	0	0	0	0	
6/29	0	0	0	0	0	0	0	0	
6/30	0	0	0	0	0	0	0	0	
7/1	0	0	0	0	0	0	0	0	
7/2	0	0	1	0	0	0	0	1	G
7/3	0	0	0	0	0	0	0	0	
7/4	0	0	0	0	0	0	0	0	
7/5	0	0	1	0	0	0	0	0	
7/6	0	0	0	0	0	2	0	0	
7/7	0	0	0	0	0	0	0	0	
7/8	0	0	0	0	0	0	0	1	P
7/9	0	0	3	0	0	0	1	3	G
7/10	0	0	5	0	0	1	0	0	
7/11[b]	0	0	10	0	0	0	0	0	
7/12[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/13[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/14[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/15[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/16[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/17[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/18	0	0	17	0	0	0	1	1	G
7/19	0	0	82	1	0	0	0	0	
7/20[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/21[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/22[c]	ND	ND	ND	ND	ND	ND	ND	ND	
7/23	0	0	136	0	0	0	0	1	P
7/24	2	0	143	0	0	0	0	2	G
7/25	0	0	296	1	0	0	0	0	
7/26	0	1	224	0	0	1	0	0	
7/27	1	0	263	0	0	0	0	0	
7/28	2	0	311	1	0	1	0	0	
7/29	1	0	346	1	0	0	0	0	
7/30	1	0	447	0	0	0	0	0	
7/31	2	1	423	1	0	2	0	0	
8/1	12	2	555	0	0	0	0	0	
8/2	1	0	533	3	0	0	0	1	P
8/3	17	0	856	1	0	1	0	0	
8/4[c]	ND	ND	ND	ND	ND	ND	ND	ND	
8/5[c]	ND	ND	ND	ND	ND	ND	ND	ND	
8/6[c]	ND	ND	ND	ND	ND	ND	ND	ND	
8/7[c]	ND	ND	ND	ND	ND	ND	ND	ND	
8/8	139	5	430	2	0	0	0	1	P
8/9	112	10	288	1	0	1	1	1	P
8/10	195	19	392	0	0	0	0	0	
8/11	146	18	342	0	0	0	0	1	G

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Appendix B1.–Page 2 of 2.

Date	Chinook Salmon	Sockeye Salmon	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden	White-fish	Other[a]	
8/12	182	36	369	0	0	0	0	1	G
8/13	194	44	346	1	0	0	0	0	
8/14	166	76	374	0	0	0	1	1	G
8/15	121	71	311	2	0	0	1	3	G
8/16	114	103	227	0	0	1	1	0	
8/17	115	159	205	0	0	0	0	0	
8/18	67	145	154	0	0	2	0	0	
8/19	82	109	113	0	0	0	0	0	
8/20	49	104	109	1	0	3	1	0	
8/21	98	157	133	0	0	1	0	0	
8/22	28	163	97	0	0	2	2	0	
8/23	19	167	110	0	0	1	0	1	P
8/24	19	139	62	0	0	0	0	0	
8/25	10	94	72	0	0	1	1	1	P
8/26	8	97	37	0	0	0	0	1	G
8/27	5	95	36	0	0	1	1	1	B
8/28	2	77	36	0	0	1	0	1	P
8/29	2	74	30	0	1	1	0	1	G
8/30	4	56	25	0	0	0	0	1	G
8/31	1	44	20	0	2	2	0	1	P
9/1	1	37	23	0	0	1	0	0	
9/2	2	45	17	0	0	1	1	0	
9/3	1	12	9	0	0	1	1	0	
9/4	1	37	9	0	0	4	1	0	
9/5	1	16	12	0	0	2	1	0	
9/6	1	19	8	0	0	1	0	0	
9/7	4	24	6	0	4	1	0	1	P
9/8[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/9[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/10[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/11[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/12[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/13[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/14[c]	ND	ND	ND	ND	ND	ND	ND	ND	
9/15	ND	ND	ND	ND	ND	ND	ND	ND	
9/16	0	1	0	0	5	0	0	1	P
9/17	0	0	0	0	5	0	0	0	
9/18	0	0	1	0	13	1	0	2	P
9/19	ND	ND	ND	ND	ND	ND	ND	ND	
9/20	ND	ND	ND	ND	ND	ND	ND	ND	
9/21	ND	ND	ND	ND	ND	ND	ND	ND	
9/22	ND	ND	ND	ND	ND	ND	ND	ND	
9/23	ND	ND	ND	ND	ND	ND	ND	ND	

[a] G= Arctic grayling; P= Northern pike; B= Burbot.

[b] Weir was inoperable due to a high water event.

[c] Weir was inoperable due to a high water event.

APPENDIX C. CLIMATE AND STREAM INFORMATION FOR THE KOGRUKLUK RIVER WEIR, 2007

Appendix C1.–Daily weather and stream observations at Kogrukluk River weir, 2007.

Date	Time	Sky Conditions[a]	Precipitation (mm)[b]	Temperature (°C) Air	Water	River Stage (cm)[c]	Water Clarity[d]
6/21	7:30	1	0.0	9	11	299	1
	17:00	1		19	12	298	1
6/22	7:30	4	1.0	9	10	296	1
	17:00	4		13	10	295	1
6/23	10:00	4	1.5	11	10	298	1
	17:00	4		12	12	304	1
6/24	10:00	4	3.0	11	9	313	1
	17:00	3		11	10	313	1
6/25	7:30	3	0.0	10	9	309	1
	17:00	3		16	12	306	1
6/26	7:30	3	0.0	9	10	303	1
	17:00	3		19	11	302	1
6/27	7:30	1	0.0	9	11	301	1
	17:00	3		19	12	300	1
6/28	7:30	4	0.3	9	10	299	1
	17:00	4		14	11	298	1
6/29	7:30	4	0.0	9	9	299	1
	17:00	4		15	10	298	1
6/30	9:00	4	1.0	12	10	298	1
	17:00	4		16	11	298	1
7/1	10:00	4	0.0	13	10	297	1
	17:00	3		19	11	296	1
7/2	7:30	4	3.6	13	12	295	1
	17:00	4		18	12	293	1
7/3	7:30	4	9.0	14	10	294	1
	17:00	3		21	13	294	1
7/4	7:30	3	7.5	16	13	295	1
	17:00	4		17	13	296	1
7/5	7:30	4	1.0	13	11	298	1
	18:30	3		22	13	296	1
7/6	7:30	3	0.5	12	11	298	1
	17:00	4		19	12	296	1
7/7	9:30	1	18.0	13	10	302	1
	17:00	2		22	12	302	1
7/8	10:00	3	0.0	13	11	296	1
	17:00	3		20	13	293	1
7/9	7:30	1	2.0	10	10	294	1
	17:00	1		22	14	295	1
7/10	7:30	2	0.0	12	12	293	1
	17:00	3		21	13	291	2
7/11	7:30	4	43.0	12	12	302	3
	17:00	4		21	12	323	3
7/12	7:30	4	11.0	11	10	359	3
	17:00	1		22	12	357	3
7/13	7:30	4	0.0	8	11	342	3
	17:00	4		18	11	334	3

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		Sky	Precipitation	Temperature (°C)		River	Water
Date	Time	Conditions[a]	(mm)[b]	Air	Water	Stage (cm)[c]	Clarity[d]
7/14	10:00	4	0.0	13	10	326	3
	17:00	4		17	10	323	2
7/15	10:00	4	0.5	13	9	319	2
	17:30	4		14	10	315	1
7/16	7:30	4	0.3	10	10	313	2
	17:00	4		16	12	312	1
7/17	7:30	3	0.0	10	10	310	1
	17:00	2		22	12	309	1
7/18	7:30	3	0.0	13	11	306	1
	17:00	3		22	13	305	1
7/19	7:30	4	1.5	12	10	306	1
	17:00	4		17	11	310	1
7/20	7:30	4	13.0	12	10	316	2
	17:00	3		20	12	322	3
7/21	10:00	4	0.6	14	11	313	2
	17:00	4		17	11	310	2
7/22	10:00	4	4.0	10	9	310	2
	17:00	4		12	10	310	2
7/23	7:30	4	0.5	10	9	310	2
	17:00	3		16	10	307	2
7/24	7:30	4	9.0	10	9	306	2
	17:30	4		14	11	307	2
7/25	7:30	3	8.0	8	9	310	2
	18:00	3		20	12	310	2
7/26	7:30	3	0.0	12	10	305	2
	17:00	2		22	13	303	2
7/27	7:30	4	0.0	13	11	301	1
	17:00	1		23	13	298	1
7/28	10:00	2	0.0	13	11	298	1
	18:00	1		19	12	294	1
7/29	10:00	4	0.0	14	11	295	1
	17:00	4		20	12	292	1
7/30	7:30	4	0.0	12	10	294	1
	18:30	4		16	12	290	1
7/31	7:30	4	10.0	11	10	294	1
	17:30	4		16	11	297	1
8/1	7:30	4	0.0	12	10	294	1
	17:00	4		14	10	298	1
8/2	7:30	4	0.5	10	9	292	1
	17:00	4		14	10	294	1
8/3	7:30	4	1.0	10	10	300	1
	17:00	4		14	10	300	1
8/4	10:00	4	5.5	11	10	303	2
	17:00	4		13	12	303	2
8/5	10:00	4	15.0	13	10	316	2
	17:00	3		17	12	317	3

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Date	Time	Sky Conditions[a]	Precipitation (mm)[b]	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[c]	Water Clarity[d]
8/6	7:30	4	0.5	11	11	318	3
	17:00	4		14	12	310	3
8/7	7:30	4	0.0	10	10	304	3
	17:00	3		18	12	304	2
8/8	7:30	4	0.0	8	10	305	1
	17:00	3		19	11	301	1
8/9	7:30	1	0.0	6	9	300	1
	17:00	1		22	12	297	1
8/10	7:30	1	0.0	5	10	298	1
	17:00	1		23	12	300	1
8/11	10:00	4	0.0	12	11	296	1
	17:00	4		17	11	291	1
8/12	10:00	3	2.5	16	11	295	1
	17:00	1		28	14	290	1
8/13	7:30	1	0.0	11	11	292	1
	17:00	1		25	14	288	1
8/14	7:30	4	2.0	9	14	291	1
	17:00	3		16	14	286	1
8/15	7:30	2	5.0	10	10	289	1
	17:00	4		15	11	291	1
8/16	7:30	4	2.0	12	10	288	1
	17:00	2		19	13	289	1
8/17	7:30	1	0.0	8	11	285	1
	17:00	2		20	12	283	1
8/18	10:00	4	2.0	8	10	283	1
	17:00	4		15	11	282	1
8/19	10:30	4	0.3	11	11	283	1
	17:00	4		17	10	281	1
8/20	7:30	4	3.0	10	10	283	1
	17:00	4		15	11	283	1
8/21	7:30	4	3.0	10	10	290	1
	17:00	4		15	11	292	1
8/22	7:30	4	1.5	10	11	291	1
	17:00	4		14	10	291	1
8/23	7:30	3	5.0	9	10	292	1
	17:00	3		18	12	294	1
8/24	7:30	1	0.0	8	10	291	1
	19:00	2		15	12	287	1
8/25	9:00	3	8.0	12	10	286	1
	17:00	2		19	12	287	1
8/26	10:00	5	0.0	5	10	288	1
	17:00	2		15	12	284	1
8/27	10:00	2	2.5	9	10	285	1
	17:00	2		19	13	288	1
8/28	10:00	2	0.0	8	10	287	1
	17:00	3		19	12	286	1

-continued-

Date	Time	Sky Conditions[a]	Precipitation (mm)[b]	Temperature (°C) Air	Water	River Stage (cm)[c]	Water Clarity[d]
8/29	10:00	3	0.0	12	10	283	1
	17:00	3		18	12	282	1
8/30	10:00	4	0.0	11	11	280	1
	17:00	4		15	11	279	1
8/31	10:00	4	0.5	11	11	278	1
	17:00	4		15	11	278	1
9/1	10:00	4	7.0	12	10	279	1
	17:00	4		16	11	278	1
9/2	10:00	4	5.0	11	10	278	1
	17:00	3		15	11	279	1
9/3	10:00	4	0.0	11	10	280	1
	17:00	4		14	10	279	1
9/4	10:00	4	0.5	9	9	280	1
	17:00	3		15	11	285	1
9/5	10:00	1	0.0	7	9	294	2
	17:00	3		16	11	293	2
9/6	10:00	2	2.0	8	9	288	2
	17:00	4		13	10	288	2
9/7	10:00	4	0.5	10	9	285	2
	17:00	4		14	9	284	2
9/8	10:00	4	5.0	12	9	285	2
	17:00	3		17	10	291	2
9/9	10:45	2	1.0	12	9	336	3
	17:00	2		18	11	314	3
9/10	10:00	4	0.0	7	9	305	2
	17:00	4		14	10	302	2
9/11	10:00	4	0.0	11	8	298	2
	17:00	4		12	8	298	3
9/12	10:00	3	0.5	8	8	304	2
	17:00	2		14	9	313	3
9/13	10:00	4	2.0	9	8	324	3
	17:00	4		10	9	316	3
9/14	10:00	4	0.5	8	8	312	2
	17:00	1		14	9	312	2
9/15	10:00	1	0.0	6	7	306	2
	19:00	2		11	8	304	2
9/16	10:00	3	0.0	6	7	302	2
	17:00	4		14	8	301	2
9/17	10:00	4	5.0	8	8	300	2
	17:00	4		13	8	300	1
9/18	10:00	4	5.0	9	8	301	1
	17:00	4		12	8	301	1
9/19	10:00	3	2.0	9	7	319	3
	17:00	3		12	8	331	3
9/20	10:00	4	0.5	8	8	318	2
	17:00	3		13	9	312	2

-continued-

Appendix C1.–Page 5 of 5.

Date	Time	Sky Conditions[a]	Precipitation (mm)[b]	Temperature (°C) Air	Temperature (°C) Water	River Stage (cm)[c]	Water Clarity[d]
9/21	10:00	3	0.5	8	8	306	2
	17:00	2		13	7	306	1
9/22	10:00	4	0.0	6	8	303	1
	17:00	4		12	8	302	1
9/23	10:00	4	0.0	5	7	300	1
	17:00	4		7	7	301	1
9/24	10:00	4	1.5	6	7	301	1
	17:00	4		9	7	297	1
9/25	10:00	4	0.5	5	6	296	1
	17:00	4		9	7	295	1
9/26	10:00	3	2.0	3	7	294	1
	17:00	4		12	7	293	1
9/27	10:00	1	0.0	3	6	292	1
Seasonal mode[e]:		4	-	-	-	-	1
Seasonal average[f]:		-	2.6	13.3	10.3	299.4	-

Note: ND = no data

[a] Sky condition Codes are: 0= no observation; 1= mostly clear (<10% cloud cover); 2= partly cloudy (<50% cloud cover); 3= mostly cloudy (> 50% cloud cover); 4= complete overcast (100% cloud cover); 5= thick fog.

[b] Represents the cumulative precipitation in the 24 hours prior to the daily morning observation.

[c] In previous reports water level was reported in millimeters. Note this distinction when comparing to past years.

[d] Water clarity codes are: 1= visibility is greater than 1.0m; 2= visibility is 0.5 to 1.0m; 3= visibility is less than 0.5m.

[e] The most frequent occurrence.

[f] Calculated from days in which 2 observation were made: one between 0730 and 1100 hours and one between 1700 and 1900 hours.

Appendix C2.–Daily stream temperature summary from Hobo® data logger at Kogrukluk River weir, 2007.

	Temperature (^oC)		
Date	Avg.	Min.	Max.
7/18	10.8	9.9	11.7
7/19	10.6	10.1	11.1
7/20	10.7	10.0	11.9
7/21	10.9	10.6	11.5
7/22	9.5	9.2	10.5
7/23	9.2	8.6	9.8
7/24	9.6	9.0	10.6
7/25	10.2	9.2	11.3
7/26	10.8	9.9	11.8
7/27	11.8	10.6	13.5
7/28	12.1	11.1	13.0
7/29	11.6	11.1	12.3
7/30	11.0	10.5	11.4
7/31	10.6	10.3	11.0
8/1	10.3	10.0	10.6
8/2	9.8	9.4	10.2
8/3	10.1	9.7	10.4
8/4	9.8	9.6	10.2
8/5	10.6	9.7	12.0
8/6	11.3	10.8	11.6
8/7	10.8	9.9	11.6
8/8	10.6	9.8	11.3
8/9	11.0	9.5	12.7
8/10	11.5	10.0	12.8
8/11	11.2	10.7	12.1
8/12	12.0	10.5	14.2
8/13	13.5	12.2	14.9
8/14	12.6	11.9	14.0
8/15	11.0	10.5	11.7
8/16	11.3	10.3	12.8
8/17	11.7	10.8	12.7
8/18	10.7	10.2	11.6
8/19	9.9	9.6	10.3
8/20	10.1	9.6	10.7
8/21	10.2	9.7	10.9
8/22	10.2	9.8	10.5
8/23	10.6	9.7	11.9
8/24	11.2	10.1	12.3
8/25	11.3	10.6	12.4
8/26	10.9	9.8	11.8
8/27	10.7	9.5	12.1
8/28	11.0	9.9	12.0
8/29	11.2	10.2	12.2
8/30	11.1	10.4	11.6
8/31	10.7	10.1	11.2
9/1	10.5	10.0	11.2
9/2	10.9	10.2	11.9
9/3	10.2	9.7	11.0
9/4	9.9	9.0	11.2
9/5	9.7	8.7	10.4
9/6	9.6	9.0	10.1
9/7	9.3	8.9	9.7
9/8	9.5	9.0	10.4
9/9	10.1	9.4	11.0
9/10	9.3	8.9	10.2
9/11	8.7	8.4	8.9
9/12	8.6	8.0	9.3
9/13	8.4	8.1	8.9
9/14	8.1	7.6	8.8
9/15	7.9	7.3	8.2
9/16	7.6	7.0	8.2
9/17	7.8	7.6	8.2
9/18	8.0	7.7	8.4
9/19	8.1	7.6	8.4
9/20	8.2	7.8	8.8
9/21	8.3	7.8	8.7
9/22	8.0	7.6	8.3
9/23	7.3	7.1	7.7
9/24	7.0	6.7	7.2
9/25	6.6	6.2	6.9
9/26	6.4	5.9	6.8
9/27	7.3	5.8	10.5
9/28	8.5	7.1	9.9
Average:	10.0	9.3	10.8

APPENDIX D. HISTORICAL SALMON ESCAPEMENT ESTIMATES AT THE KOGRUKLUK RIVER WEIR

Appendix D1.–Summary of annual passage estimates for Kogrukluk River 1976–2007.

	Chinook				Chum				Sockeye				Coho[a]			
Year	Obs.[b]	Est.[c]	Total[d]	%[e]	Obs.[b]	Est.[c]	Total[d]	%[e]	Obs.[b]	Est.[c]	Total[d]	%[e]	Obs.[b]	Est.[c]	Total[d]	%[e]
1976	5,507	93	5,600	1.7	8,046	71	8,117	0.9	2,302	24	2,326	1.0				
1977[f]	1,385	0	1,385	n.a.	10,388	0	10,388	n.a.	1,112	0	1,112	n.a.				
1978	13,132	535	13,667	3.9	47,099	1,026	48,125	2.1	1,646	24	1,670	1.4				
1979	10,125	1,213	11,338	10.7	13,966	4,633	18,599	24.9	2,432	196	2,628	7.5				
1980	843	0	843	87.2	6,323	0	6,323	84.9	404	0	404	87.4				
1981	16,070	737	16,807	4.4	56,271	1,101	57,372	1.9	17,702	374	18,076	2.1	11,450	5	11,455	0.0
1982	5,325	5,668	10,993	51.6	41,204	20,655	61,859	33.4	11,729	5,568	17,297	32.2	35,582	2,214	37,796	5.9
1983	1,082	1,943	3,025	64.2	3,248	837	4,085	65.5	375	0	375	68.1	8,327	211	8,538	2.5
1984	4,928	0	4,928	0.0	41,484	0	41,484	0.0	4,133	0	4,133	0.0	25,304	2,291	27,595	8.3
1985	4,287	332	4,619	7.2	13,843	1,162	15,005	7.7	4,344	15	4,359	0.3	14,618	1,823	16,441	11.1
1986	2,922	2,116	5,038	42.0	12,041	2,652	14,693	18.1	3,255	992	4,247	23.4	14,717	7,789	22,506	34.6
1987[g]	770	3,293	4,063	81.1	2,365	15,057	17,422	86.4	284	689	973	70.8	19,756	3,065	22,821	13.4
1988	7,665	855	8,520	10.0	28,499	11,044	39,543	27.9	4,240	162	4,402	3.7	11,722	1,790	13,512	13.3
1989[h]	4,911	7,029	11,940	58.9	15,543	24,004	39,547	60.7	2,599	3,211	5,810	55.3	1,272	0	1,272	n.a.
1990	10,097	121	10,218	1.2	26,555	210	26,765	0.8	8,383	24	8,407	0.3	2,736	3,396	6,132	55.4
1991	5,868	1,982	7,850	25.3	22,369	1,819	24,188	7.5	13,737	2,718	16,455	16.5	7,059	2,905	9,964	29.2
1992	6,397	358	6,755	5.3	31,902	2,202	34,104	6.5	7,344	195	7,539	2.6	2,712	23,519	26,231	89.6
1993	10,516	1,817	12,333	14.7	26,764	5,137	31,901	16.1	27,148	2,218	29,366	7.6	4,395	16,122	20,517	78.6
1994	8,305	6,922	15,227	45.5	23,147	23,488	46,635	50.4	5,695	8,497	14,192	59.9	27,057	7,638	34,695	22.0
1995	18,877	1,774	20,651	8.6	28,460	2,805	31,265	9.0	10,582	414	10,996	3.8	17,492	10,370	27,862	37.2
1996	13,764	435	14,199	3.1	47,095	1,383	48,478	2.9	15,222	164	15,386	1.1	47,011	3,544	50,555	7.0
1997	13,111	173	13,284	1.3	7,902	56	7,958	0.7	13,059	18	13,077	0.1	11,611	627	12,238	5.1
1998	3,009	9,098	12,107	75.1	13,013	23,428	36,441	64.3	5,321	11,452	16,773	68.3	22,614	1,734	24,348	7.1
1999	5,472	98	5,570	1.8	13,497	323	13,820	2.3	5,777	87	5,864	1.5	10,094	2,515	12,609	20.0
2000	3,180	130	3,310	3.9	11,077	414	11,491	3.6	2,776	89	2,865	3.1	32,875	260	33,135	0.8
2001	6,572	2,726	9,298	29.3	22,551	8,019	30,570	26.2	6,637	2,139	8,776	24.4	18,308	1,079	19,387	5.6
2002	9,590	514	10,104	5.1	49,494	2,076	51,570	4.0	3,913	137	4,050	3.4	14,501	15	14,516	0.1
2003	11,585	186	11,771	1.6	22,514	899	23,413	3.8	8,986	178	9,164	2.0	68,718	5,886	74,604	7.9
2004	19,432	219	19,651	1.1	24,174	27	24,201	0.1	6,767	8	6,775	0.1	26,078	963	27,041	3.6
2005	21,731	269	22,000	1.2	191,588	6,135	197,723	3.1	37,465	474	37,939	1.2	23,102	1,014	24,116	4.2
2006	19,184	230	19,414	1.2	176,508	4,086	180,594	2.3	59,773	1,034	60,807	1.7	12,811	4,200	17,011	24.7
2007	6,923	6,106	13,029	46.9	31,421	18,084	49,505	36.5	10,004	6,521	16,525	39.5	23,796	3,237	27,033	12.0

[a] Coho migrations were not monitored prior to 1981.

[b] The sum of annual observed passage.

[c] The sum of annual estimated passage (i.e. passage estimates that were calculated for inoperable periods).

[d] The sum of total observed passage and total estimated passage.

[e] The percentage of total passage that was estimated (i.e. not observed).

[f] Estimates were made from counting tower data and are not included in the "Estimated Total".

[g] Chinook, chum, and sockeye escapements were estimated from a ratio of unknown 1987 escapement and known 1987 aerial assessments to known 1988 weir escapement and known 1988 aerial assessment. Coho escapements were estimated using time series techniques.

[h] Heavy rain and high river levels allowed only 2 days of counts during the coho migration. As a result, total escapement was not estimated.

APPENDIX E. KOGRUKLUK RIVER WEIR SALMON BROOD TABLES

Appendix E1.–Brood table for Kogrukluk River Chinook salmon.

Brood Years	Escapement (spawners)	Number by Age in Return Year						Returns[a]	Return per Spawner[a]
		3	4	5	6	7	8		
1968	ND	ND	ND	ND	ND	ND	0	-	-
1969	-[b]	ND	ND	ND	ND	24	ND	-	-
1970	-[b]	ND	ND	ND	2,847	ND	0	-	-
1971	-[b]	ND	ND	2,301	ND	2,054	0	-	-
1972	-[b]	ND	428	ND	7,830	352	-	-	-
1973	-[b]	0	ND	1,433	1,851	-	0	-	-
1974	-[b]	ND	2,327	1,630	-	649	0	-	-
1975	-[b]	24	7,505	-	9,774	597	0	-	-
1976	5,600	0	-	5,096	7,106	128	4	-	-
1977	1,385	-	1,243	2,588	1,690	171	5	5,692[c]	4.11
1978	13,667	45	698	594	1,301	148	0	2,741	0.20
1979	11,338	4	606	2,341	2,072	365	-	5,384[d]	0.47
1980	6,572[e]	7	1,106	1,647	1,652	-	0	-	-
1981	16,809	4	746	2,563	-	678	-	-	-
1982	10,993	0	433	-	2,672	-	0	-	-
1983	3,025	22	-	4,479	-	30	0	-	-
1984	4,928	-	678	-	1,148	83	-	-	-
1985	4,625	0	-	6,288	4,677	-	-	-	-
1986	5,038	-	2,463	2,264	-	-	-	-	-
1987	4,063[f]	293	479	-	-	-	0	-	-
1988	8,520	0	-	-	-	48	0	-	-
1989	11,940[f]	-	-	-	10,427	964	0	-	-
1990	10,214	-	-	4,827	3,639	55	-	-	-
1991	7,850	-	3,614	7,801	6,034	-	0	-	-
1992	6,755[e]	0	1,788	2,715	-	86	0	-	-
1993	12,332[e]	0	4,481	-	3,749	59	0	-	-
1994	15,227[e]	0	-	1,418	1,294	143	0	-	-
1995	20,630	-	303	1,630	4,070	143	0	6,146[c]	0.30
1996	14,499	14	327	3,656	3,149	330	0	7,462	0.53
1997	13,286	0	1,425	5,054	4,234	121	0	10,834	0.82
1998	12,107[e]	0	1,754	5,011	3,643	207	0	10,615	0.88
1999	5,570	0	2,196	7,105	6,172	831	0	16,304	2.93
2000	3,310	0	8,782	10,228	5,707	380	ND	-	-
2001	9,297	0	5,337	5,998	4,137	ND	ND	-	-
2002	10,099	56	6,776	4,301	ND	ND	ND	-	-
2003	11,771	102	4,212	ND	ND	ND	ND	-	-
2004	19,651	0	ND	ND	ND	ND	ND	-	-
2005	22,000	ND	ND	ND	ND	ND	ND	ND	ND
2006	19,414	ND	ND	ND	ND	ND	ND	ND	ND
2007	13,029	ND	ND	ND	ND	ND	ND	ND	ND

[a] Returns do not include downstream harvest.

[b] Escapement was monitored with a counting tower; annual escapement data are not comparable to weir data.

[c] Does not include any possible 3 year old fish.

[d] Does not include any possible 8 year old fish.

[e] Insufficient age data.

[f] Insufficient escapement data.

Appendix E2.–Brood table for Kogrukluk River chum salmon.

Brood Years	Escapement (spawners)	Number by Age in Return Year 3	4	5	6	Returns[a]	Return per Spawner[b]
1969	-[c]	ND	ND	ND	ND	-	-
1970	-[c]	ND	ND	ND	113	-	-
1971	-[c]	ND	ND	4,913	ND	-	-
1972	-[c]	ND	3,072	ND	0	-	-
1973	-[c]	22	ND	23,716	ND	-	-
1974	-[c]	ND	24,031	ND	0	-	-
1975	-[c]	378	ND	157	368	-	-
1976	8,117	ND	1,487	48,390	39	-	-
1977	10,388	0	8,607	25,656	-	-[b]	-
1978	48,125	0	38,382	-	534	-	-
1979	18,599	0	-	7,205	75	-	-
1980	6,323	-	33,754	10,703	343	-	-
1981	57,372	0	4,188	3,774	-	-	-
1982	61,859	37	10,513	-	ND	-	-
1983	4,094	69	-	ND	-	-	-[d]
1984	41,484	-	ND	-	378	-	-
1985	15,005	ND	-	8,477	0	-	-
1986	14,693	-	17,532	10,066	277	-	-
1987	2,365	378	14,013	18,320	1,587	34,297[b]	-[d]
1988	39,543	105	14,617	19,452	-	-[b]	-
1989	39,547	906	10,860	-	246	-[b]	-[d]
1990	26,765	0	-	15,088	788	-	-
1991	24,188	-	13,355	13,953	51	-	-
1992	34,104	411	32,893	4,448	-	-	-
1993	31,901	860	3,404	-	47	-	-
1994	46,635	34	-	6,965	35	-[b]	-
1995	31,265	-	6,807	3,565	0	-	-
1996	48,494	0	7,750	12,542	551	20,843	0.43
1997	7,958	141	17,874	11,912	136	30,063	3.78[e]
1998	36,441	148	39,028	7,426	41	46,643[b]	-[d]
1999	13,820	79	15,431	14,952	0	30,462	2.20[e]
2000	11,491	420	15,182	11,002	471	27,075	2.36
2001	30,570	6,939	178,882	65,060	1,479	252,360	8.26
2002	51,570	7,839	112,256	17,291	ND	-	-
2003	23,413	2,811	29,321	ND	ND	-	-
2004	24,201	1,415	ND	ND	ND	-	-
2005	197,723	ND	ND	ND	ND	ND	ND
2006	180,594	ND	ND	ND	ND	ND	ND
2007	49,505	ND	ND	ND	ND	ND	ND

[a] Returns do not include downstream harvest.

[b] Insufficient age data.

[c] Escapement was monitored with a counting tower; annual escapement data are not comparable to weir data.

[d] Insufficient escapement data.

[e] Does not include any possible 3 year old fish.

Appendix E3.–Brood table for Kogrukluk River coho salmon.

Brood Years	Escapement (spawners)	Number by Age in Return Year 3	4	5	Returns[a]	Return per Spawner[b]
1981	11,455	ND	ND	ND	-[b]	-
1982	37,796	ND	ND	ND	-[b]	-
1983	8,538	ND	ND	ND	-[b]	-
1984	27,595	ND	ND	ND	-[b]	-
1985	16,441	ND	ND	604	-[b]	-
1986	22,506	ND	5,169	223	-[b]	-
1987	22,821	357	9,565	ND	-[b]	-
1988	13,512	175	ND	134	-[b]	-
1989	1,272[c]	ND	4,071	2,880	-	-
1990	6,132	108	31,259	1,320	32,687	5.33
1991	9,964	504	16,743	1,068	18,315	1.84
1992	26,057[c]	775	47,970	ND	-	-
1993	20,517	1,511	ND	1,029	-	-
1994	34,695	ND	22,915	1,184	-	-
1995	27,862	401	11,109	680	12,190	0.44
1996	50,555	317	32,117	1,395	33,829	0.67
1997	12,238	338	17,699	1,967	20,004[b]	1.63
1998	24,348	293	12,550	12,585	25,428	1.04
1999	12,609	0	60,942	3,175	64,117	5.08
2000	33,135	1,227	23,700	2,201	27,128	0.82
2001	19,387	166	20,470	485	21,121	1.09
2002	14,516	1,445	14,715	1,560	17,720	1.22
2003	74,604	1,812	24,527	ND	-	-
2004	27,041	946	ND	ND	-	-
2005	24,116	ND	ND	ND	ND	ND
2006	17,011	ND	ND	ND	ND	ND
2007	27,033	ND	ND	ND	ND	ND

Note: Escapement monitoring at Kogrukluk River weir dates back to 1969; however, coho salmon monitoring did not begin until 1981.

[a] Returns do not include downstream harvest.

[b] Insufficient age data.

[c] Insufficient escapement data.